Erasmus School of Economics

ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics

Master Thesis Economics and Business
Health Economics

THE MARGINAL EFFECT OF HOSPITAL SPENDING ON CANCER MORTALITY IN THE NETHERLANDS.

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Date final version: October 29, 2023
Wordcount: 11,311

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Abstract

Healthcare spending on cancer in the Netherlands is expected to increase in the upcoming forty years by on average 5.4 percent per year. Hospital spending on cancer accounts for more than eighty percent of healthcare spending on cancer. The increasing costs of cancer raise complex questions regarding the returns. Does hospital spending on cancer result in a better life expectancy and is increasing hospital spending worth it?

Most research focuses on general healthcare spending or average returns, while the aim of this research is to estimate the marginal returns of hospital spending on cancer in the Netherlands. To estimate the marginal effect, regression analyses including fixed effects are conducted using data from the period 2003-2021. Specific attention is paid to colorectal, lung and breast cancer since hospital spending is highest for these cancer subgroups. Regression analyses are conducted for three scenarios regarding the lagged effects of hospital spending: non-lagged effects, one-year lagged effects and two-year lagged effects.

Although average hospital spending increased more than average mortality rates declined, the results of the analyses do not indicate that hospital spending caused a decline in cancer mortality. The marginal effects of hospital spending on mortality suggest that increasing hospital spending on breast, lung, total and the remaining types of cancer with one percent, leads to an increase of less than one percent in the mortality rate. Only the analysis including lagged effects of colorectal cancer showed a decrease in mortality of less than one percent if hospital spending increased with one percent. Translating these estimates into cost-effectiveness thresholds based on opportunity costs within the healthcare sector, would lead to extremely high cost-effectiveness thresholds.

All in all, the results of the conducted research suggest that an increase in hospital spending does not result in a lower mortality rate and therefore increasing hospital spending on cancer is not cost-effective. The results suggest that treatments and pharmaceuticals which account for a large part of the hospital spending not always lead to the preferred outcome. The research emphasizes the need for better goal-targeted hospital spending considering the expected increase in the need for cancer treatment the upcoming forty years, the importance of considering marginal effects instead of average effects and using an individual approach towards the different cancer types instead of considering cancer as one group of illness.

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Chapter 1. Introduction

Healthcare spending on cancer in the Netherlands has increased in the last century and is expected to increase in the upcoming forty years by on average 5.4 percent per year (CBS, 2022a; Vonk & et al., 2020). Cancer, cardiovascular diseases, and dementia form the three groups of illnesses with the highest healthcare spending in the Netherlands. However, the average yearly percentage growth for healthcare spending for the upcoming forty years is expected to be higher for cancer than for cardiovascular diseases and dementia (RIVM, 2022; Vonk et al., 2020). Data on cancer spending in 2019 illustrates that hospital spending accounts for more than eighty percent of healthcare spending, furthermore it is worth noting that most cancer expenses were incurred for breast, colorectal and lung cancer. Between 2003 and 2019 healthcare spending on colorectal cancer doubled while healthcare spending on lung and breast cancer even quadrupled (RIVM, 2020; RIVM, 2022).

The increase in cancer costs is mainly caused by the development of new, more expensive technologies and pharmaceuticals used in the detection and treatment of cancer (KWF, 2014; RIVM, 2018). The high contribution of more than eighty percent of hospital spending in total healthcare spending reflects the high-tech and specialized character of the detection and treatment of cancer. Improved detection technologies increase the chance of cancer detection in an early stadium. The detection of breast cancer is a recent example of this, due to improved detection technologies and subsidized screening programs the detection of breast cancer in an early stadium increased (IKNL, 2023).

Treatment consists of combinations of surgery, chemotherapy, radiotherapy, immunotherapy, and gene therapy. The treatment is more effective when cancer is in early stadium in which nearby tissue is not damaged yet (Vonk et al., 2020). The expensive pharmaceuticals used in treatment are prescribed and administered in hospitals. The expenditures on pharmaceuticals have increased by nearly a billion in five years and half the costs of expensive drugs are attributable to cancer treatment. The expectation is that this percentage is going to increase due to the rising number of patients treated with expensive pharmaceuticals and the rising costs of the development of pharmaceuticals (Vektis, 2023).

Healthcare expenditures on cancer do not only occur in hospitals but also in, for instance, primary care, public care, prevention, and elderly care. However, these other expenditures only form less than twenty percent of total healthcare expenditures on cancer

(RIVM, 2017). It is not expected that hospital spending on cancer is going to decrease in the next forty years considering the developments on cancer treatment and detection that are in the pipeline (Vonk et al., 2020).

The increasing hospital spending on cancer raises questions regarding the returns. Does hospital spending on cancer result in a better life expectancy? In the Netherlands, the cancer mortality rate shows a decrease since the late 1980s (CBS, 2020). Based on only this information, it seems that increased hospital spending results in improved life expectancy. However, other factors, for instance a healthier lifestyle including more physical exercise and healthier food could also reduce the mortality rate (Zhang et al., 2020). The factors that could, in combination with increasing hospital spending or on its own, reduce the mortality rate make it hard to tell what the actual effect of hospital spending on the mortality rate is.

If hospital spending on cancer increases the life expectancy, questions concerning the cost-effectiveness of cancer treatment arise. Given the amount of spending and the size of the effect, is it worth spending on cancer? While sometimes it might seem obvious that higher average hospital spending results in a lower mortality rate, it is less obvious whether a marginal increase in hospital spending lowers the mortality rate. Therefore, it is harder to tell if increasing hospital spending on cancer is worth it. More money could be spent on providing more healthcare or better healthcare and therefore the mortality rate might decrease, but if there is a small increase in spending it is less obvious if it will lower the mortality rate. This depends on whether and to what extent hospital spending compared to other factors causes the improved life expectancy (van Baal et al., 2013).

While most research focuses on general healthcare spending or average returns, this study focuses on the marginal returns of hospital spending and might be useful for decision making including cost-effectiveness implications on the effect of hospital spending on cancer mortality in the Netherlands.

1.1. Relevance

The aim of this thesis is to estimate whether increased hospital spending on cancer lowered mortality in the Netherlands and to consider the cost-effectiveness implications if increased hospital spending indeed causes a lower mortality rate. The research elaborates on existing literature by focusing on marginal returns. The analyses are conducted for all types of cancer and for colorectal, lung and breast cancer separately as these are the types of cancer with the highest healthcare and hospital expenditures.

1.2. Reader's guide

Trends in hospital spending and mortality including the current standings regarding the returns and cost-effectiveness implications are discussed in more detail in the theoretical framework section. The data and empirical strategy section elaborates on the dataset and presents the conducted model. The findings of the conducted analyses are provided in the results section. In the discussion and conclusion section a critical evaluation regarding the strengths and limitations of the research is presented, the key findings and their practical relevance are discussed, and recommendations for future research are made.

Chapter 2. Theoretical framework

To examine the effect of increased hospital spending on mortality it is important to thoroughly understand the underlying causes of increased hospital spending and the determining factors of mortality. Moreover, it is important to understand the existing literature regarding the effect of hospital spending on mortality including the cost-effectiveness implications.

2.1. Trends in hospital spending

Healthcare spending on cancer in the Netherlands has increased in the last century and is expected to increase in the upcoming forty years by on average 5.4 percent per year (CBS, 2022a; Vonk & et al., 2020). Hospital spending makes up more than eighty percent of healthcare spending (RIVM, 2022). Data on the costs of cancer show that in 2019 most healthcare spending was on breast, colorectal and lung cancer (RIVM, 2022).

Cancer is most often detected and treated in hospitals because it is a complex disease. Hospital operating costs could be segregated into overhead, outpatient, inpatient and ancillary costs (Bai & Zare, 2020). Hospital spending related to cancer, largely consist of expensive equipment and pharmaceuticals, software costs, personnel costs, and research on new pharmaceuticals. Various factors exert an influence on cancer hospital spending. Main drivers of hospital spending on cancer are the stadium of the cancer, the increasing incidence and prevalence of cancer and the development of new treatment options and pharmaceuticals (KWF, 2014; RIVM, 2018).

Wong et al. (2011) show the effect of the proximity of death on hospital spending. The last year of life hospital costs for, especially, cancer patients are high due to the intensity of the treatment caused by the late stadium of the cancer. Therefore, the stadium of the cancer could be a good predictor of hospital spending. The biggest effect was found for the most lethal diseases. The most lethal stadium of cancer is stadium IV in which the cancer has spread to distant parts of the body. Lung cancer is a lethal type of cancer that is often discovered in stadium IV (KWF, 2017). Patients in stadium IV receive the highest intensity treatment which is correlated to high hospital spending (Wong et al., 2011).

The IKNL (2022a) predicts that the incidence of cancer will increase in the upcoming ten years. The number of people that need cancer treatment already increased from 120,000 patients per year in 2017 to 150,000 patients in 2021 (VWS, 2022). The expectation is 232,000 new patients in 2032. The increasing incidence of cancer is mainly caused by the growing and ageing population. If more people are alive, and the life expectancy keeps increasing, it is more likely that the incidence and therefore the prevalence of cancer increases. However, the lifestyle of the population plays an important role in the incidence. Unhealthy behavior includes smoking, drinking alcohol, eating unhealthy food and a lack of exercise (RIVM, 2018). Among patients with lung cancer, 86 percent contracted the condition as a consequence of smoking. On top of that, there seems to be a relation between obesity and colorectal and breast cancer (MMC, 2018; Stichting tegen kanker, 2023). Between 2017 and 2021 obesity and the lack of exercise among people increased while smoking and alcohol usage decreased (CBS, 2018; CBS, 2022b). Although the incidence and prevalence of cancer increased, hospital spending increased relatively more than the number of patients (RIVM, 2018). This means that despite the role of incidence and prevalence in the increasing hospital spending, these factors are not the key drivers of the increasing hospital spending.

The development of new detection and treatment methods including new pharmaceuticals need investments from, among others, hospitals. According to the IKNL (2022a) numerous improved (early) detection methods capable of discovering small tumors, play a limited role in the increasing incidence of cancer but do play a big role in the prevalence and prevention costs of cancer. Spending on pharmaceuticals has increased by around a billion in five years and cancer treatment is responsible for half of the costs of expensive pharmaceuticals (Vektis, 2023). Prices of new treatment options and pharmaceuticals are high as a result of the granted patents. A patent includes market exclusivity which means developers can ask high prices for the pharmaceuticals and treatment options. As soon as the patent expires, more suppliers enter the market and the prices decline. Horizon scanning of the Zorginstituut Nederland shows that a substantial amount of cancer drugs is still in the pipeline, mainly for breast and lung cancer. Therefore, the expectation is that costs of pharmaceuticals will not decrease in the near future (Zorginstituut Nederland, 2022).

2.2. Trends in mortality

Between 2003 and 2019 per capita hospital spending on cancer tripled while the cancer mortality rate decreased by twenty percent (RIVM, 2020; RIVM, 2022; CBS, 2020). The decrease in mortality rates might be caused by hospital spending but could also be caused by other mechanisms. Recent literature emphasizes the difficulties, including a small trial and accounting for potential reverse causality, in proving a causal relation between hospital spending and the mortality rate (van Baal et al. 2013; Chow, 2022). Therefore, it is important to understand the other mechanisms that might affect the mortality rate. Cancer mortality rates are driven by hospital spending, lifestyle factors, the demographical development, and prevention.

Lifestyle factors that influence the mortality rate are nutrition, physical activity, smoking and drinking alcohol (RIVM, 2023). Between 2017 and 2021 obesity and the lack of exercise among people increased while smoking and alcohol usage decreased (CBS, 2018; CBS, 2022b; CBS 2023a). If cancer patients start living healthier, the mortality might decrease or be postponed. Given this information, it is hard to tell if the observed average decrease in mortality is caused by less smoking and alcohol usage, by the increased hospital spending on cancer or a combination of both.

Demographical developments include the composition of gender and age groups. Women tend to have a higher life expectancy than men and men have a greater susceptibility to developing cancer (van Duin et al., 2012; Kiemeney et al., 2008; Jackson et al., 2002). For women, the likelihood of developing cancer increases gradually with age, while for men it seems to increase sharply from middle age on (Kuijpens, 2008). Therefore, if the population is relatively young instead of old, it seems more likely that the mortality is lower even though hospital spending is still increasing. Risky behaviors contributing to the lifestyle of the population might show patterns for different ages and gender groups (IKNLa, 2022).

Prevention plays an important role in lowering the mortality rate and is often subsidized by the government (RIVM, 2011). Examples of prevention include campaigns to improve the lifestyle of the population and screening programs. Lifestyle factors focus on preventing cancer and screening focuses on detecting cancer in an early stadium in which cancer is more treatable. Njor et al. (2015) conducted a study in Denmark estimating the effect of breast cancer screening on the mortality rate and concluded that a 22 percent reduction in mortality could be attributed to screening. The study started before the introduction of the screening program which allowed the researchers to use a natural experiment to collect the data. Therefore, it could be the case that although hospital spending is increasing and mortality rates are decreasing, the actual cause of the decreasing mortality rates is prevention and not the increasing hospital spending.

2.2. Returns on hospital spending

Up until now, studies trying to estimate the return of hospital spending are mostly conducted in small trials, meaning the focus is on insolated medical interventions in strictly defined patient groups before the introduction of the intervention (van Baal et al., 2013). Conducting trials under these circumstances makes it difficult to generalize the results to the whole population. Therefore, these studies do not give enough evidence of the causal effect of healthcare spending on mortality. Other methodological issues consist of the impossibility of randomized control trials due to ethical concerns and the difficulty of controlling for reverse causality and omitted variable bias. These issues may indicate that other mechanisms might explain the observed trends in hospital spending and mortality. Most research up until now focuses on total healthcare spending on cancer and average returns.

On the one hand, Chow et al. (2022) express their concerns about the increasing costs of cancer and the still high cancer mortality rate. Among 22 rich countries in 2022, the Netherlands has an above average cancer mortality rate and above average cancer costs per capita. This raises questions on the effectiveness of cancer spending, the cost-effectiveness policies and if the EMA is not too flexible in permitting new pharmaceuticals and treatments.

On the other hand, Stevens et al. (2015) argue that cancer mortality reductions were greatest among countries where cancer care spending rose the most. Countries with the highest spending growth between 1995 and 2000 experienced a 17 percent decrease in amenable mortality, mortality that can be avoided by timely and effective treatment, while countries with the lowest growth in spending experienced an eight percent decrease. NCR shows that the survival probability curve in the Netherlands shifted upwards over the last sixty years (NCR, 2022). However, it is questionable if the curve shifted upwards due to increased hospital spending on cancer and if it shifted upwards enough to be cost-effective, meaning the mechanism causing the curve to shift offer value for money (van Baal et al., 2013).

Nevertheless, Stadhouders et al. (2019) and van Baal et al. (2019) actually focused on the marginal returns instead of average returns of respectively, general healthcare and cardiovascular disease (CVD) hospital spending using a time fixed effect translog model. Stadhouders et al. (2019) only used data from the years 2012 until 2014 while van Baal et al. (2019) considered data from 1994 until 2010. Reverse causality could occur due to high last year of life costs meaning that mortality rates cause changes in hospital spending. Stadhouders et al. (2019) addressed reverse causality by segregating the healthcare spending into last year of life costs and costs unrelated to mortality. However, to correct for reverse causality by using last year of life costs, assumptions such as the independence of the last year of life costs from changes in mortality should be made. Van Baal et al. (2019) tried to control for reverse causality by using lagged effects, and discussed the limited impact of last year of life costs for CVD as the time to death is less strong for CVD compared to other diseases such as cancer. Stadhouders et al. (2019) address the omitted variable bias by using differences in the number of patients as proxy for health trends and including time fixed effects. Using the number of patients as proxy for health trends carries along several assumptions. If the treatment intensity and outcomes change while the number of patients stays the same or if healthier patients are attracted as soon as the actual number of patients decrease, the number of patients as proxy for health trends might not be a good way to address omitted variables. Van Baal et al. (2019) address the omitted variables by taking first differences, year-specific varying intercepts, and varying intercepts for trends in CVD mortality. Other studies also tried to correct for omitted variables by attributing a fixed part of the returns to other factors than medical care (Cutler & McClellan, 2001; Hall & Jones, 2004).

2.4. Cost-effectiveness

If a marginal increase in hospital spending causes a decrease in the cancer mortality rate, the cost-effectiveness becomes crucial. The main question being put forth is whether the marginal effect of hospital spending on mortality is of such a considerable size that it is worth it to increase hospital spending. Even though it seems logical that a lower mortality rate is more favorable, a critical assessment of the cost-effectiveness should be made because money is scarce and hospital spending on cancer could also be spent on other illnesses or even on other important aspects to society unrelated to healthcare if the effect is more rewarding.

Most studies focusing on the returns of hospital spending are conducted before the introduction of an intervention. These studies might be useful for reimbursement decisions. However, post-ante evaluations, meaning after the intervention, might be useful to calculate cost-effectiveness thresholds that could be used for future interventions. Reimbursement decisions are usual based on comparing the new potential treatment with an alternative by calculating the expected incremental cost-effectiveness ratio (ICER) and comparing the ICER to the cost-effectiveness threshold. The thresholds are typically calculated considering the societal perspective, meaning the focus is on the willingness to pay for a quality-adjusted life year (QALY). The threshold calculated in this way is referred to as the v-threshold or the consumption value of health (Ryen & Svensson, 2014). In the Netherlands, the cost-effectiveness v-thresholds range between 20,000 and 80,000 Euros per QALY depending on the severity of the disease (Zwaap et al., 2015).

Recent discussions have suggested that the cost-effectiveness may be examined by focusing on the opportunity costs within the healthcare sector (Pandey, 2018). This healthcare perspective focuses on the marginal returns to medical care and the calculated threshold is also referred to as the k-threshold. The v-threshold addresses the societal perspective but might be of value for the healthcare perspective since it shows if the healthcare budget is optimally allocated. Moreover, the k-threshold might be of importance for the societal perspective because it presents the opportunity costs of a healthcare intervention substituting another intervention, or the costs of expanding treatment instead of substituting treatment, or the costs of limiting current treatments. Research on the k-threshold of cancer treatments in the Netherlands has not yet been conducted.

However, the k-threshold for cardiovascular disease in the Netherlands has been estimated using a life-table approach and showed a threshold of 41,000 Euros per QALY gained (van Baal et al., 2019). Meerding et al. (2007) conducted research on the average returns of cancer spending between 1953 and 2003 in the Netherlands. The returns are calculated by combining the incidence, survival, and mortality rates with data on the introduction of medical innovations. The results show an average return of cancer spending below the 20,000 Euros per QALY threshold. In England, the k-threshold is used for reimbursement decisions due to a fixed healthcare budget per region. Nevertheless, the QALY gains are equally valued with no attention to the severity of the disease which gets less accepted over time. Due to differences in the healthcare and reimbursement systems it is not possible to compare/adjust the estimates for the Netherlands (McCabe et al., 2012; Zwaap et al., 2015).

Chapter 3. Data and empirical strategy

First, comprehensive information on the dataset including trends of hospital spending and mortality is presented. Thereafter, the regression analyses are explained in depth.

3.1. Data

Data on cancer hospital spending is provided by the cost of illness studies in the Netherlands (RIVM, 2017; RIVM, 2019a; RIVM, 2019b; RIVM, 2020; RIVM, 2022). The cost of illness studies allocate hospital costs to disease, gender, and age groups by using the Dutch hospital Discharge Register that provides information on inpatient admissions and average length of stay. The cost of illness studies are published every four years, for the intervening two-year period data is extrapolated based on demographical information (RIVM, 2020). Data on hospital spending ranges between 2003 and 2019, with missing data in 2009. Furthermore, data on hospital spending on lung, colorectal and breast cancer is not available for the year 2015. Breast cancer among men is not considered, because hospital spending and mortality rates are negligible (RIVM 2017; CBS 2022b). Data is collected for men and women with a minimum age of fifty years and the age categories capture five years. Younger men and women are not included because hospital spending is relatively low compared to the elderly and therefore the dataset captures the most detailed information if the elderly is included (RIVM, 2020).

Hospital spending is translated into spending per capita by dividing the hospital spending by the average population size provided by the CBS (CBS, 2023b). The average population size is calculated by taking the average of the population size on the first of January of the relevant year and the population size on the first of January of the next year. Besides, hospital spending per capita is corrected for price developments by indexing the prices based on the GDP price development in the Netherlands using 2017 as base year (CBS, 2023c).

Data on mortality caused by cancer attributed to gender and age categories is collected from the mortality register set up by the CBS (CBS, 2022c). Mortality data ranging from 2003 until 2021 is collected. The register contains information on the underlying causes of death of Dutch inhabitants following the guidelines of the WHO, meaning there can only be one registered underlying cause of death. The final registered cause of death is the illness/event that led to death, although there could have been other circumstances that played a role. The mortality data is translated into mortality rates by dividing the mortality by the average population size provided by the CBS (CBS, 2023b).

3.2. Trends in spending and mortality

Hospital spending per capita and the mortality rates for all cancer types between 2003 and 2019 per gender and age category are presented in Figure 1. For both, men, and women, hospital spending and mortality does not follow a normal distribution but instead is skewed to the left.

In general, spending and mortality is higher for men than for women. Hospital spending is not only higher for men but increased more for men as well. Between the ages 75 and 80 spending per capita is highest for men while for women this is between 70 and 75 years. At the same time, the average life expectancy of men in the Netherlands has increased from 76 to 81 while the life expectancy of women increased from 81 to 84 between 2003 and 2019 (The World Bank, 2023). The increase for men is almost twice that for women what might, in combination with a higher risk of developing cancer, explain the bigger increase in spending. Although the mortality for men is higher than for women, the mortality rate for men in figure 1 shows a clear decline between 2003 and 2019 while the mortality rate for women shows smaller, less clear declines and even shows an increase in mortality for women aged 80 and above.

Overall, hospital spending increased for both men and women while the fluctuations in mortality rate are smaller and show bigger decreases for men than for women.

Figure 1

Hospital spending per capita in Euros on cancer and mortality rates per age category in years over the period 2003-2019.

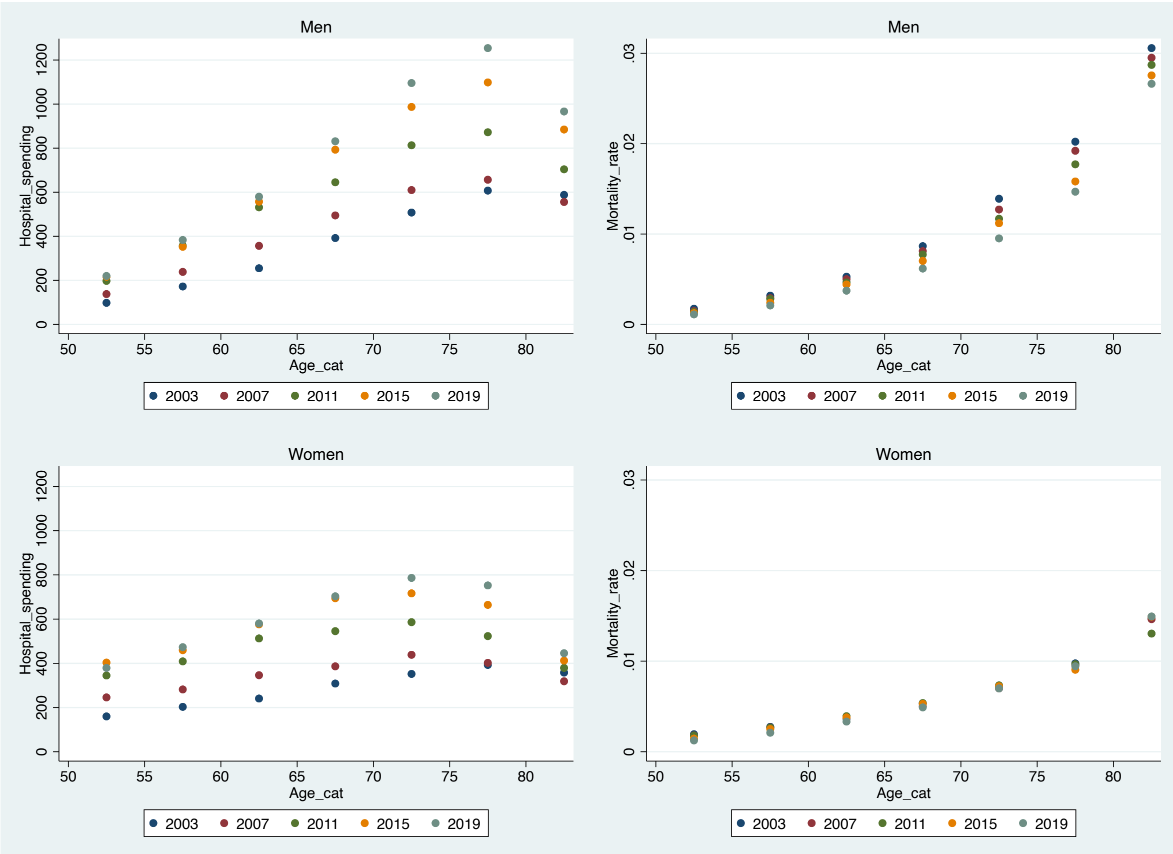


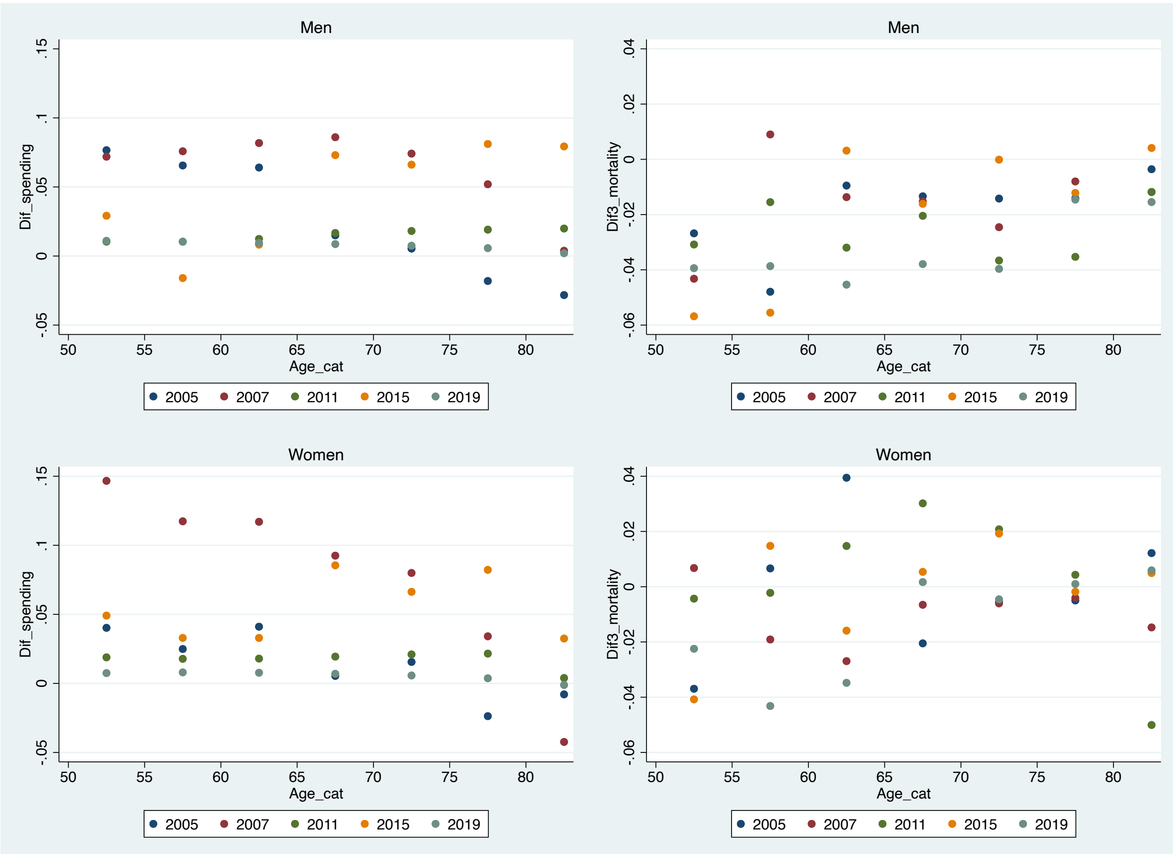
Figure 2 presents the first differences of the logarithms of hospital spending per capita and the mortality rate. Logarithms of hospital spending and mortality rates are taken to interpret the results as elasticities and to deal with the left-skewed distribution. First differences are taken to be able to measure marginal effects. The first differences of the year 2011 capture differences of four years while the other observations capture first differences of two years.

Almost all first differences of hospital spending show positive results, only for the oldest age categories some negative first differences occur. This means that hospital spending in almost all cases increased, which is in accordance with the graphs in figure 1. In general, the first differences for the year 2007 are for both men and women relatively high until the age of 75. From the age of 75 the first differences of the year 2015 are the highest. This means, for people until the age of 75 hospital spending increased the most between 2005 and 2007 and for men and women aged 75 and above, hospital spending increased the most between 2013 and 2015.

Figure 2 shows the most variation in first difference logarithms of mortality rates between the ages 55 and 65 for both men and women. The first difference mortality rates for men mainly show negative differences meaning the mortality rate decreased, while for women more positive first differences are observed. Nevertheless, most first differences for women are also negative. The clear decrease in mortality rates for men and the less clear fluctuations for women were already observed in figure 1.

Figure 2

First difference hospital spending per capita in Euros on cancer and first difference mortality rates per age category in years over the period 2003-2019.



Hospital spending per capita and the mortality rate for colorectal, lung and breast cancer per gender and per age category for the period 2003 until 2019 are presented in figure 3. Hospital spending per capita on colorectal and lung cancer increased between 2003 and 2019 with the highest spending among men. Nevertheless, in 2011, hospital spending was higher than in 2019 for both men aged 60 and older, as well as for women aged 60 to 80. Moreover, hospital spending on colorectal cancer decreased between 2003 and 2019 for men and women aged

80 and above. The life expectancy in combination with a shift in cancer prevalence or policy changes regarding treatment options for elderly might explain the decrease in spending. Hospital spending on colorectal cancer is highest for men and women between 75 and 80 years, while for lung cancer spending for women is highest between 65 and 75 years of age and for men between 75 and 80 years. Hospital spending on breast cancer is higher than hospital spending on colorectal and lung cancer. Spending on breast cancer increased as well between 2003 and 2019. Highest spending per capita is reached between 65 and 75 years. Hospital spending per capita on breast cancer experienced the biggest increases between 2003 and 2011 compared to lung and colorectal cancer. Between 2011 and 2019 the incremental changes in hospital spending are smaller, but hospital spending on breast cancer in these years is still the highest compared to lung and colorectal cancer.

Mortality caused by lung cancer decreased for men, while the mortality rate for women aged 60 and above increased between 2003 and 2019. The mortality rate caused by lung cancer for men 60 years and older is at its lowest in 2011 compared to the mortality rates in 2003 and 2019. The mortality rates of lung cancer are the highest for both, men, and women, compared to the mortality caused by colorectal and breast cancer. Mortality caused by colorectal cancer decreased for men between 2003 and 2019. Besides, the mortality rate for men aged 80 and above increased between 2011 and 2019. The mortality caused by colorectal cancer for women only shows smaller, less clear, decreases between 2003 and 2019 for the 60 years and older. Mortality caused by breast cancer shows small fluctuations and differences in increases and decreases between 2003 and 2019. The mortality rate decreased the most for women aged 70 and above.

In general, hospital spending per capita increased for colorectal, lung, and breast cancer, while the mortality rates showed smaller fluctuations and showed more clear, bigger, decreases for men than for women. The same general conclusion was drawn based on figure 1 showing hospital spending and mortality on cancer in total.

Figure 3

Hospital spending per capita in Euros on different types of cancer and mortality rates per age category in years over the period 2003-2019.

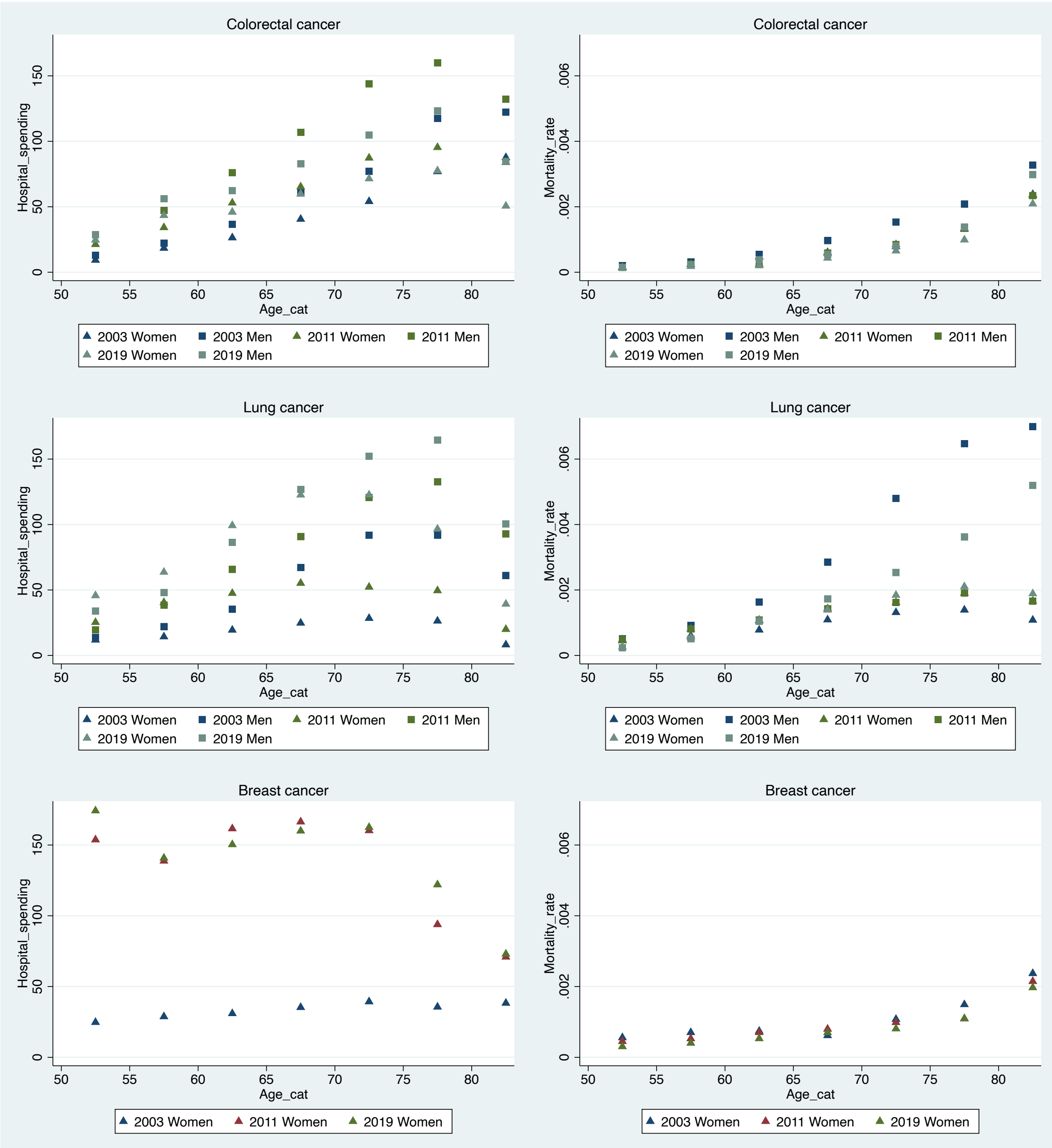


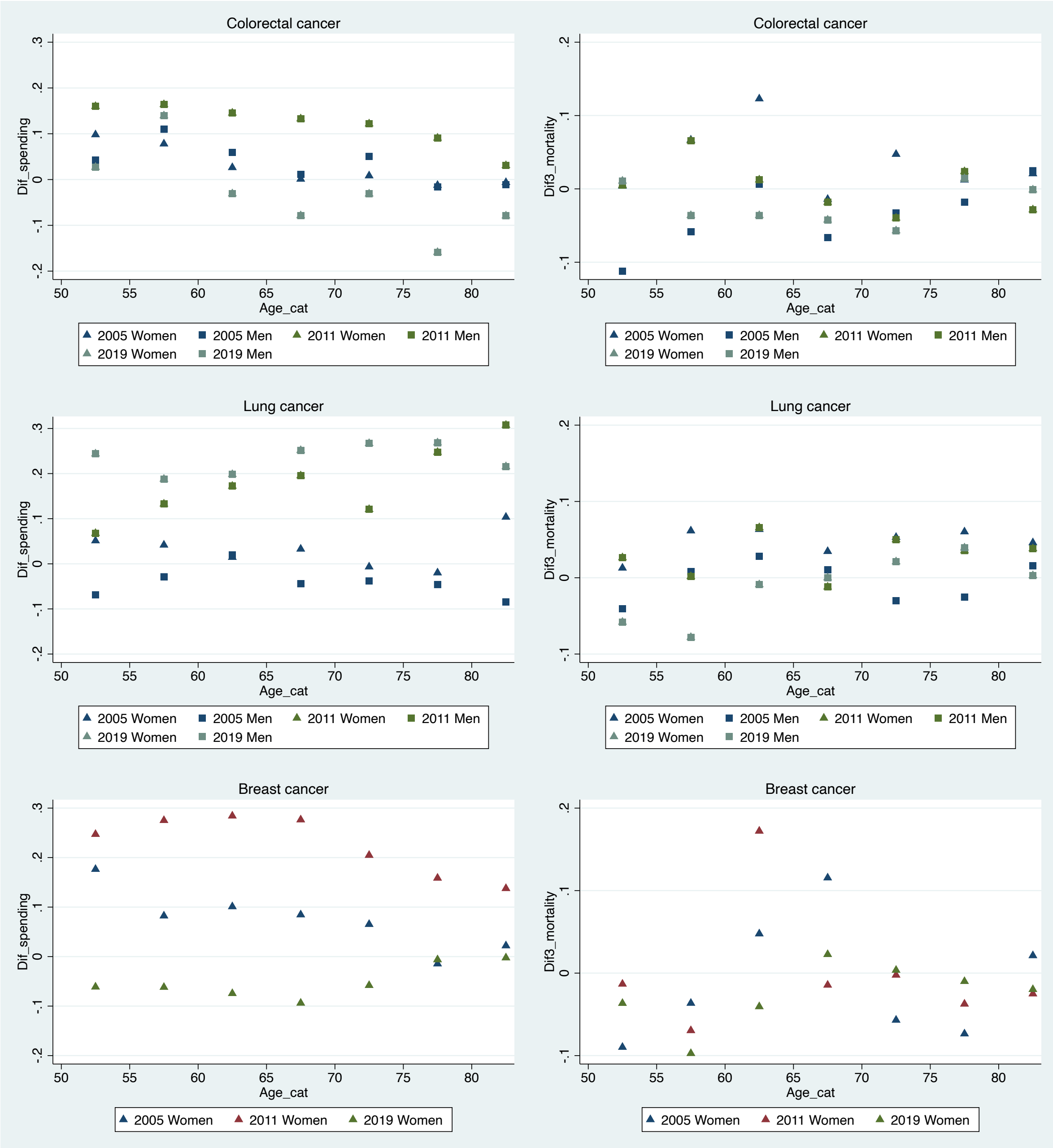
Figure 4 shows the first differences in the logarithms of hospital spending per capita and mortality rates for colorectal, lung and breast cancer. First differences of the year 2011 capture four year first differences while the other observations capture two year first differences.

The biggest fluctuations in the first differences of hospital spending and mortality rate occur for breast cancer, which is in accordance with figure 3. The first differences of hospital spending for breast cancer are positive except for the first differences of the year 2019, those differences are negative meaning hospital spending between 2017 and 2019 decreased. The first differences of hospital spending on lung cancer show positive results except for the year 2005, almost all first differences of 2005 for men are negative and for women the first differences are small but mainly positive. The first differences of hospital spending on colorectal cancer are positive until the age of 60. From the age of 60 the first differences of 2019 for both men and women are negative. The first differences of the year 2005 and 2011 start to show smaller differences from the age of 60 compared to men and women aged between 50 and 60.

The first difference mortality rates of breast cancer are mainly negative, however, for the women aged between 60 and 70 years first differences are relatively big and mainly positive. The first difference mortality rates of lung cancer are mainly positive but the fluctuations in the first differences of mortality rates are smaller compared to breast and colorectal cancer. The first difference mortality rates of colorectal cancer show mainly negative results. However, there are some relatively big positive outliers for men and women aged between 55 and 65 years.

Figure 4

First difference hospital spending per capita in Euros on different types of cancer and first difference mortality rates per age category in years over the period 2003-2019.



3.3. Regression analyses

Regression analyses including fixed effects are conducted to examine the effect of hospital spending on mortality.

The regression analyses are conducted for cancer in total, colorectal, lung, and breast cancer separately to ensure the estimates capture the most relevant information possible and to prevent double counting the effects of the subtypes of cancer in the total cancer regression. On top of that, a separate regression analysis is conducted for the remaining cancer types, meaning total cancer subtracted by colorectal, lung and breast cancer.

The variable of interest is the first difference of the logarithm of mortality, for year t and i number of observations considering the gender and age categories. The independent variable is the first difference of the logarithm of hospital spending per capita for time t and i number of observations. Logarithms of the mortality rate and hospital spending per capita are taken to be able to interpret the estimates as elasticities and to deal with the left-skewed distributions visible in figure 1 and 3. First differences of mortality and hospital spending consider the panel data characteristics of the dataset to correct for differences in mortality rates not caused by hospital spending but by any other time invariant unobserved variable such as the increased mortality risk for elderly.

To correct for time variant variables that affect hospital spending and mortality among men and women of all ages in the same way, year-specific trends are added to the regression. Examples of such time variant factors include government policies or bans on lifestyle factors such as drinking alcohol or smoking or policies regarding hospital care. To adjust for time variant variables that affect men and women at different ages in a different way, such as lifestyle factors and the severity of the disease, an interaction term between gender and age is included in the regression. The interaction term is not included in the analysis considering breast cancer since men are not considered. The fixed effects eliminate the time invariant part of the error term, meaning only the time variant part of the error term is modelled. Formula 1 shows the conducted regression analysis in scenario A.

$$\Delta \log(M_i^t) = \beta_0 + \beta_1 \Delta \log(S_i^t) + \beta_2 Y_i + \beta_3 I_i + u_{it} \quad (1)$$

Where:

- M_i^t = mortality rate for time t and for i number of observations
- S_i^t = hospital spending per capita for time t and for i number of observations
- β_0 = intercept parameter (constant)
- β_1 = coefficient for hospital spending per capita; S
- β_2 = coefficient for year-specific trends; Y
- β_3 = coefficient for interaction term between gender and age; I
- u_{it} = error term

The effect of hospital spending on mortality is expected to last for at least one year, therefore a straightforward regression would underestimate the effect of hospital spending on mortality. To correct for using calendar years, a one-year lagged effect of hospital spending (S_i^{t-1}) is taken into consideration in the regression analysis. Formula 2 shows the conducted regression analysis in scenario B.

$$\Delta \log(M_i^t) = \beta_0 + \beta_1 \Delta \log(S_i^{t-1}) + \beta_2 Y_i + \beta_3 I_i + u_{it} \quad (2)$$

To take into consideration the heavily concentrated hospital spending on cancer in the last year of life and research showing the effect of hospital spending on mortality could have an impact for more than one year, a bigger lagged effect is included (Luyendijk et al., 2023; Wong et al., 2011). In scenario C a two-year lagged effect (S_i^{t-2}) instead of a one-year lagged effect (S_i^{t-1}) of hospital spending is considered. Formula 3 shows the conducted regression analysis in scenario C.

$$\Delta \log(M_i^t) = \beta_0 + \beta_1 \Delta \log(S_i^{t-2}) + \beta_2 Y_i + \beta_3 I_i + u_{it} \quad (3)$$

3.3.1. Validity and Reliability

The regression analysis including fixed effects is associated with several assumptions to examine an unbiased and efficient effect. The model is able to account for the correlation between the time invariant part of the error term and the variable of interest, mortality, due to the inclusion of fixed effects of mortality and hospital spending. The between variation is eliminated so the focus is on within variation.

For the regression to be unbiased the strict exogeneity assumption should hold. This means the idiosyncratic shock, the time variant part of the error term, should be uncorrelated with hospital spending. Reverse causality and the omitted variable bias must be addressed in the conducted regression analyses to make sure this assumption holds. Reverse causality occurs when mortality is causing a change in hospital spending instead of hospital spending causing a change in mortality. This could occur due to the high last year of life costs, meaning a high mortality would lead to higher hospital spending. Omitted variable bias refers to not being able to include all relevant variables in the regression analyses. The preferred model to account for reverse causality and omitted variables is the instrumental variable approach because it isolates the exogenous variation to estimate causal effects. Individual level data, such as data on the patient, specific hospital, or regional level, is needed to create a strong, valid, and relevant instrument. Unfortunately, only data on the country level is available. The alternative is lagged effects as instruments, however assumptions as no direct effect on the dependent variable and/or unobserved confounders need to be made (Wang & Bellemare, 2019).

Since individual level data is not available and using lagged effects as instruments depends on crucial assumptions, the instrumental variable approach does not seem the most appropriate method to ensure strict exogeneity. Therefore, lagged effects of hospital spending are used to control for reverse causality. However, in the non-lagged effect analysis (formula 1, scenario A) reverse causality could occur. Nevertheless, literature on the returns of hospital spending and the recent prevention programs does not suggest reverse causality (Stevens et al., 2015; NCR, 2022; IKNL, 2020). Year-specific trends and an interaction term of gender and age are added to the regression capturing time varying health shocks and trends in age and gender groups to address the omitted variable bias. It is not possible to include all individual omitted variables in the regression analysis because not all factors that could influence hospital spending, such as for instance the severity of the disease, could be measured. Therefore, the health shocks and trends in age and gender groups are a good alternative given the available data to address the time varying factors that could influence hospital spending. For the regression analysis to be efficient the serial correlation of the error terms should be addressed, this is controlled for by clustering the standard errors.

The other multiple linear regression assumptions that should hold for the model are linearity in parameters, random sampling, and no perfect collinearity. No sample is drawn, the whole population of the Netherlands is considered and therefore random sampling is an irrelevant assumption. Linearity in parameters and no perfect collinearity are met, meaning there cannot be interactions between the parameters and there is no perfect linear relationship between explanatory variables. For inference, two additional assumptions must hold. There should be a normal distribution of the error term and the variance of the error term should be the same regardless of the value of the independent variables. The normal distribution is created by taking logarithms of the mortality rate and hospital spending per capita, homoskedasticity is created by taking robust clustered errors.

Chapter 4. Results

This chapter presents the results of the conducted regression analyses. Table 1 presents the estimates of the conducted regression analyses for hospital spending on mortality for total, colorectal, lung, breast cancer and the remaining types of cancer. Scenario A consists of non-lagged effects (formula 1), scenario B represents the regression analysis considering a one-year lagged effect (formula 2), while scenario C refers to the regression analyses considering a lagged effect of two years (formula 3). All interpretations of the estimates are ceteris paribus, meaning all other factors are constant.

Table 1

Estimates of the effect of cancer hospital spending on cancer mortality considering a non-lagged effect of spending (scenario A), a one-year lagged effect of spending (scenario B) and a two-year lagged effect (scenario C).

Mortality	Number of observations	Scenario A Non-lagged effect of spending (β_1)	Scenario B One-year lagged effect of spending (β_1)	Scenario C Two-year lagged effect of spending (β_1)
Cancer in total	98	0.163**	0.198***	0.044
		(0.062)	(0.062)	(0.066)
Colorectal cancer	84	0.170	-0.260	-0.017
		(0.224)	(0.193)	(0.117)
Lung cancer	84	0.240***	0.272***	0.106
		(0.070)	(0.076)	(0.117)
Breast cancer	42	0.229	0.242	0.003
		(0.199)	(0.129)	(0.105)
Remaining	84	0.129	0.248**	0.192*
		(0.108)	(0.903)	(0.899)

Note. Robust standard errors in parentheses, ***p<0.01 **p<0.05 * p<0.1.

The estimates of the regression analyses in scenario A show only positive effects of hospital spending on mortality. All estimates show that if hospital spending is increased by one percent, mortality rates will increase with less than one percent. The estimate of 0.163 percent for total cancer is significant at the five percent level. The estimate of 0.240 percent for lung cancer is significant at the one percent level. The estimates of 0.170, 0.229 and 0.129 for relatively, colorectal, breast and the remaining cancer types are not significant at the ten percent level.

If scenario B is considered, including one year-lagged data on hospital spending, the regression analysis on colorectal cancer shows that a one percent increase in hospital spending causes a decrease of 0.260 percent in the mortality rate, compared to an increase of 0.170 percent in scenario A. The estimate is not significant at the ten percent level. The regression analyses on lung and breast cancer show that a one percent increase in hospital spending leads to an increase of, respectively 0.272 and 0.242 percent in mortality. The estimate for lung cancer is significant at the one percent level, the estimate for breast cancer is not significant at the ten percent level. Cancer in total and the remaining cancer types show an increase of respectively, 0.198 and 0.248 percent in mortality, if hospital spending increases with one percent. The result for total cancer is significant at the one percent level, the estimate for the remaining types of cancer is significant at the five percent level.

A two-year lagged effect instead of a one-year lagged effect is considered in the regression analyses in scenario C. The magnitudes of the estimates in scenario C are lower compared to scenario A and B. The regression analysis considering all types of cancer shows that a one percent increase in hospital spending leads to a 0.044 percent increase in mortality. The result is not significant at the ten percent level. The analyses for lung- and breast cancer show that a one percent increase in hospital spending leads to an increase in mortality of respectively, 0.106 and 0.003 percent. Both estimates are not significant at the ten percent level. The estimate for the remaining types of cancer shows that a one percent increase in hospital spending causes an increase of 0.192 percent in cancer mortality. The estimate is significant at the ten percent level. On the other hand, the estimate for colorectal cancer shows a negative result of 0.017 meaning that a one percent increase in hospital spending decreases mortality by 0.017 percent. This result is not significant at the ten percent level.

An explanation for the estimates involves the treatability of certain types of cancer based on the stadium of the cancer at the time of diagnosis. Breast cancer is one of the types of cancer that is more often discovered in one of the first stadia of cancer due to screening programs (IKNL, 2020). Therefore, breast cancer is more treatable and mortality rates are lower compared to less treatable cancer types. For more treatable cancers, the association between hospital spending and mortality could become clearer when considering a larger lagged effect to capture the effect of patients living longer. The analysis of breast cancer considering a two-year lagged effect shows a smaller positive estimate compared to the non-lagged and one-year lagged effect analyses. The estimates for breast cancer are not significant at the ten percent level.

Lung cancer can be categorized as less treatable and therefore a smaller lagged effect would capture the full effect of hospital spending (IKNL, 2022b). The non-lagged and one-year lagged effect analyses show a bigger positive effect of hospital spending on mortality and are significant at the one percent level, compared to the analysis with two-year lagged effects. The indication of the strength of an estimate refers to the magnitude of the estimate.

Colorectal cancer is a type of cancer that is in between breast and lung cancer regarding the treatability of the disease (IKNL, 2022b). The one-year lagged effect analysis shows the strongest negative effect of hospital spending on mortality. All estimates are not significant at the ten percent level.

The cancer in total and the remaining cancer types consist of treatable and less treatable cancer types and therefore show some mixed effects. In all scenarios the estimates are positive, the strongest effects are estimated in the one-year lagged effect analysis. The estimate for the non-lagged effect analysis and one-year lagged analysis for total cancer are significant at the respectively, five and one percent level. The estimate for the remaining types of cancer is significant at the five percent level in the one-year lagged effect analysis and significant at the ten percent level for the two-year lagged effect analysis.

4.1.1. Sensitivity analysis

To examine the behavior of the regression coefficients shown in table 1, robustness checks are performed.

The lack of yearly data does not allow the interaction term of age and gender to capture a linear trend in mortality. The time difference created by the first differences is not constant and therefore the data limitation makes it hard to impossible to interpret the coefficient of the interaction term between age and gender. Therefore, it is useful to see if and how the effect changes if interaction terms between age and gender are not included.

Table 1 shows the estimates of the regression analyses including the interaction term between age and gender, table 2 presents the estimates of the regression analyses without the interaction term. Important to mention is that no men were included in the analyses of breast cancer and therefore it is impossible to create the interaction term between age and gender.

Table 2

Robustness check estimates of the effect of cancer hospital spending on cancer mortality without the interaction between age and gender.

Mortality	Number of observations	Scenario A Non-lagged effect of spending (β_1)	Scenario B One-year lagged effect of spending (β_1)	Scenario C Two-year lagged effect of spending (β_1)
Cancer in total	98	0.162**	0.194***	0.043
		(0.059)	(0.057)	(0.063)
Colorectal cancer	84	0.169	-0.260	-0.019
		(0.213)	(0.184)	(0.110)
Lung cancer	84	0.253***	0.293***	0.128
		(0.068)	(0.073)	(0.116)
Breast cancer	42	0.229	0.242	0.003
		(0.199)	(0.129)	(0.105)
Remaining	84	0.129	0.251**	0.192**
		(0.103)	(0.086)	(0.086)

Note. Robust standard errors in parentheses, ***p<0.01 **p<0.05 * p<0.1.

Table 2 shows some relatively small fluctuations in the estimates and statistical significance compared to table 1. The magnitude of the percentages of total cancer and colorectal cancer differs between 0.001 and 0.004 and the significance remains unchanged. The magnitude of the percentages for lung cancer is at most 0.023 higher and the significance stays as it is. The estimates for the remaining types of cancer only changed for the one-year lagged effect analysis, for which the percentage is 0.003 higher. The two-year lagged effect is significant at the five percent level instead of the ten percent level.

In general, the changes in magnitude and statistical significance are relatively small, indicating that the estimates of hospital spending on mortality are robust. However, the changes for the lung cancer estimates are relatively larger. This suggests that the approach of including the interaction term of age and gender to capture a trend in time variant factors influencing the effect of hospital spending on mortality seems appropriate. This means that although the interaction term does not capture a linear trend it still captures a trend that could help explain the effect of hospital spending on mortality.

Chapter 5. Discussion and conclusion

In this chapter an evaluation including strengths and limitations of the conducted research is given. Thereafter, a conclusion including practical implications and recommendations for future research is presented.

5.1. Discussion

The discussion consists of the strengths and the limitations of the conducted research. First the strengths are discussed after which the limitations are addressed.

5.1.1. Strengths

One of the strengths of the research is that it addresses marginal effects instead of the most often discussed average effects. The resulting practical implications are therefore more realistic as it represents the effect of spending one more Euro on the mortality rate. If average effects are taken into consideration, the actual effect of spending on mortality becomes less clear which also makes it harder to tell if the effect on mortality is caused by hospital spending or other factors related to increased hospital spending or decreased mortality rates.

Another strength is the individual approach towards several cancer types combining the results of the analyses and current literature. In interpreting the estimates of the conducted analyses for the different cancer types, literature on active prevention programs and the treatability of the different cancer types is used. This contributes to the explanation of the estimates and emphasizes the importance of the individual approach towards cancer types and not considering all cancer types as the same group of illness. The individual approach towards cancer types leads to more realistic practical implications and useful insights into cost-effectiveness implications.

An additional strength is that the research considers the whole population and does not work with small trials, therefore assumptions regarding samples do not have to be made and the study represents the Dutch population.

5.1.2. Limitations

The main limitation of the conducted research concerns the available data. Firstly, data is not available on the individual level, but only at the country level. Data on the individual level would have been more insightful since it captures more details on the specific developments, for instance regarding the severity of cancer, of a patient. Next to this, individual level data could have been used to create a strong, valid, and relevant instrument to improve the empirical design of the research. Secondly, data on cancer hospital spending is limited. The data is not available every year but consists of two-year gaps. On top of that, hospital spending on cancer for the year 2009 is not published and hospital spending for the year 2013 is not available for lung, colorectal and breast cancer. Unfortunately, recent years are not published yet, so hospital spending of the year 2021 is not yet available. Due to the data limitation, it is impossible to include a larger lagged effect than two years, while these estimates might have been useful since the impact of the hospital spending on mortality could be measured over a longer period of time. Moreover, too much data got lost if the non-lagged and lagged effects of hospital spending were included in the same regression analysis. Therefore, the instantaneous impact could not be measured in combination with the lagged effect which would have been useful considering the high last year of life costs related to cancer (Wong et al., 2011).

Another limitation concerns the impossibility to test for and fully control for potential reverse causality. Reverse causality could occur due to the high last year of life costs related to the stadium of cancer (Wong et al., 2011). This would mean higher mortality rates are related to higher hospital spending. This potential is partly addressed by including lagged effects. However, reverse causality could play a role in the regression analysis without lagged effects. Nevertheless, literature on the returns of hospital spending and the recent prevention programs do not suggest potential reverse causality (Stevens et al., 2015; NCR, 2022; IKNL, 2020).

Moreover, first-differences, year-specific trends and time varying health trends in gender and age categories are included to account for important factors that were not measurable and could influence the effect of hospital spending on mortality. However, these trends never fully represent all potential important factors and therefore the full impact of some important factors could not have been included. An option would have been to include specific time variant factors instead of trends, however not all these factors are measurable per year for the different gender and age groups in the Netherlands. The severity of the disease is such an important factor that does influence hospital spending and the mortality rate but is hard to measure, also due to the fact that individual level data is not available. However, average percentages of lifestyle factors such as smoking and alcohol usage are available, but the average percentages do harm the validity of the conducted research. On top of that, adding specific data might, if the data is available, be more accurate but it is very likely that omitted variable bias occurs since it is hard to include for instance all individual lifestyle factors in the analysis. The sensitivity analysis not including the health trends, shows that it is appropriate and useful to include the trends in health for age and gender groups. A robustness check including data on smoking, alcohol, obesity was not possible due to the data not including all age categories used in the regression analyses (CBS, 2023d).

5.2. Conclusion

The final chapter of the conducted research consists of the conclusion, the practical implications in which the results of the research are translated into a practical definition and suggestions for future research.

5.2.1. Conclusion

In this research, regression analyses considering fixed and lagged effects are conducted to estimate the marginal effect of cancer hospital spending on mortality in the Netherlands among people with a minimum age of fifty years. Although average hospital spending increased more than average mortality rates declined, the results of the analyses do not suggest that hospital spending caused a decline in cancer mortality.

The marginal effects of hospital spending on mortality suggest that increasing hospital spending on breast, lung, total and the remaining types of cancer with one percent, leads to an increase of less than one percent in the mortality rate. Only the analyses including lagged effects of colorectal cancer showed a decrease of less than one percent if hospital spending increased with one percent. In general, the estimates suggest that mortality caused by cancer has become more expensive, meaning increasing hospital spending on cancer is not worth the money.

Although data limitations are present and assumptions regarding the reverse causality and the omitted variable bias are needed to conduct the research, the research controlled as much as possible for these potential biases given the available data. Therefore, it could nevertheless be stated that the study provides useful insights into hospital spending and cancer mortality.

5.2.2. Practical implications

The research contributes to the policy debate on the healthcare investment decisions. The estimates suggest that increasing hospital spending on cancer leads in most of the considered scenarios to a higher mortality rate. Therefore, the recommendation would be to not increase hospital spending on cancer if the goal is a lower mortality rate. If the estimates were to be translated into cost-effectiveness thresholds based on the opportunity costs within the healthcare sector, assuming effects are measured in QALY's based on age and time to death, the thresholds would be extremely high. The reason for this is that there are other investments within the healthcare sector that could be made that would lead to better outcomes than increasing hospital spending on cancer with a higher mortality rate as return.

On top of that, the results suggest that treatments and pharmaceuticals which account for a large part of the hospital spending, not always lead to the preferred outcome (KWF, 2014; RIVM, 2018). Taking into account the expectation that the incidence of cancer will increase due to the growing and ageing population size, the recommendation is to better target healthcare expenditures and be more critical in permitting new pharmaceuticals and treatment options (IKNL, 2022a). This could be a recommendation towards EMA and the government but also to hospitals which could be more critical in investment decisions on the development of new treatment and pharmaceutical options.

The research emphasizes the importance of considering marginal effects and the cancer types separately. Although average hospital spending increased more than average mortality rates declined, the results of the analyses do not suggest that hospital spending caused a decline in cancer mortality. Moreover, the regression analyses on the different cancer types for the different scenarios regarding the lagged effects, showed differences in magnitude and sign. This emphasizes policy makers to take on an individual approach regarding the different cancer types and to not blindly consider only the average trends of healthcare spending and returns.

5.2.3. Future research

There are several recommendations for future research on the effect of hospital spending on mortality.

First of all, future research could focus on collecting more data to be able to fully understand the effect of hospital spending on mortality. More data on the hospital spending allows larger lagged effects and allows the non-lagged and lagged effects to be added to the same regression analysis. Next to this, more data will increase the precision of the estimates which would increase the internal validity. Moreover, more data on the individual level should be collected to control for the potential reverse causality and omitted variable bias.

In addition, future research could focus on achieving insights into regional hospital spending and mortality rates and even into the data related to academic and other hospitals in the Netherlands but also in other countries. This regional and discipline variation might separate important patient characteristics, for instance, it is known that in Zuid-Limburg the patients are used to a less healthy lifestyle maybe it might be the case that spending one more Euro on cancer leads to a very different effect than spending one more Euro in Amsterdam. Also, a segregation of hospital spending per hospital or region might generate useful insights in for instance the cost-effectiveness of cancer drugs, to some extent prevention programs, and detection methods.

Furthermore, mortality rates, or indirectly life expectancy, is the most hopeful but at the same time only one of the optional returns of hospital spending. Highest hospital spending on cancer is incurred for stadium IV cancer, while stadium IV cancer is the most lethal (Wong et al., 2011). It might be debated that quality of life in this stadium is more important than survival, since quality of life might improve even if time alive does not (Felce & Perry, 1995). Therefore, the returns in this conducted study might be underestimated. Future research could focus on more returns and other care sectors to capture an integrated effect improving the completeness of the effect of healthcare spending. Focus could for instance be on palliative care and the quality of care measured through the QLQ-C30 questionnaire (EORTC, 2023).

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