Network for Studies on Pensions, Aging and Retirement

Netspar PANEL PAPERS

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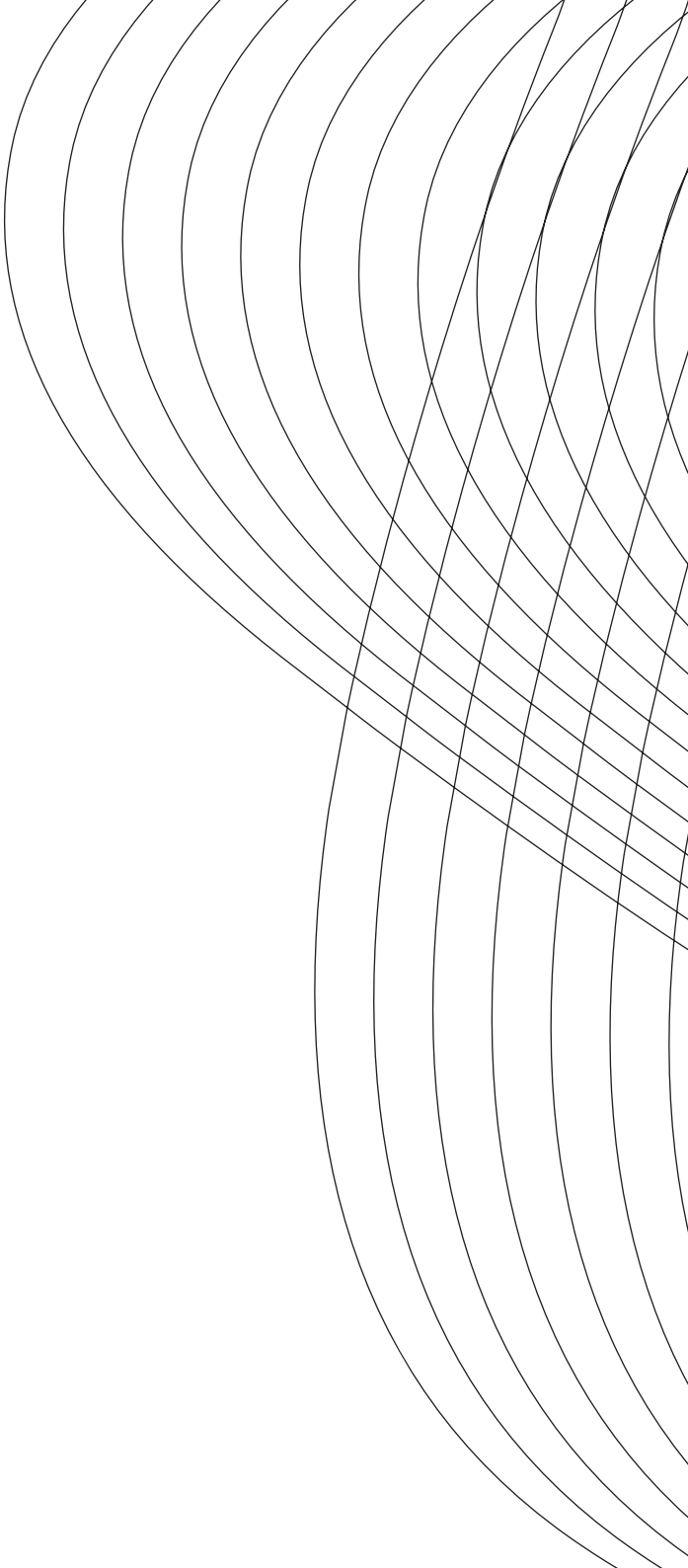
The influence of health care spending on life expectancy



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CONTENTS

PREFACE

Netspar stimulates debate and fundamental research in the field of pensions, aging and retirement. The aging of the population is front-page news, as many baby boomers are now moving into retirement. More generally, people live longer and in better health while at the same time families choose to have fewer children. Although the aging of the population often gets negative attention, with bleak pictures painted of the doubling of the ratio of the number of people aged 65 and older to the number of the working population during the next decades, it must, at the same time, be a boon to society that so many people are living longer and healthier lives. Can the falling number of working young afford to pay the pensions for a growing number of pensioners? Do people have to work a longer working week and postpone retirement? Or should the pensions be cut or the premiums paid by the working population be raised to afford social security for a growing group of pensioners? Should people be encouraged to take more responsibility for their own pension? What is the changing role of employers associations and trade unions in the organization of pensions? Can and are people prepared to undertake investment for their own pension, or are they happy to leave this to the pension funds? Who takes responsibility for the pension funds? How can a transparent and level playing field for pension funds and insurance companies be ensured? How should an acceptable trade-off be struck between social goals such as solidarity between young and old, or rich and poor, and individual freedom? But most important of all: how can the

benefits of living longer and healthier be harnessed for a happier and more prosperous society?

The Netspar Panel Papers aim to meet the demand for understanding the ever-expanding academic literature on the consequences of aging populations. They also aim to help give a better scientific underpinning of policy advice. They attempt to provide a survey of the latest and most relevant research, try to explain this in a non-technical manner and outline the implications for policy questions faced by Netspar's partners. Let there be no mistake. In many ways, formulating such a position paper is a tougher task than writing an academic paper or an op-ed piece. The authors have benefitted from the comments of the Editorial Board on various drafts and also from the discussions during the presentation of their paper at a Netspar Panel Meeting.

I hope the result helps reaching Netspar's aim to stimulate social innovation in addressing the challenges and opportunities raised by aging in an efficient and equitable manner and in an international setting.

Roel Beetsma
Chairman of the Netspar Editorial Board

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THE INFLUENCE OF HEALTH CARE SPENDING ON LIFE EXPECTANCY

Policy recommendations

Developed countries spend an increasing portion of their Gross Domestic Product (GDP) on health care with the aim to improve population health. However, as the percentage of GDP that is spent on health care increases, this raises concerns about the rate of return on these investments. In this Netspar panel paper, we summarize the findings of studies that have tried to establish a causal link between health care spending and health outcomes as measured by mortality and/or life expectancy. The focus on mortality and life expectancy is relevant for both policymaking and the Netspar initiative. One of the major threats to the sustainability of pension systems in the Netherlands is the unexpectedly rapid growth of life expectancy in recent years. If this increase is, in fact, a result from additional health care spending, this raises important inter-sectoral policy questions. For instance, for the affordability of future pensions it is relevant to know whether further increases in health care spending are likely to lead to further increases in life expectancy. If health care is found to have a strong influence on life expectancy, expanding health care spending then also has consequences for public provisions like social insurance and for pension liabilities.

Based on our literature review, we conclude that, although a causal influence of health care spending on life expectancy has been difficult to demonstrate in empirical studies, it is highly likely that increases in health care expenditures have contributed to the growth of life expectancy in Western countries. This conclusion has several implications for the Netherlands. Since

health care spending has increased in the Netherlands, a part of this increase has probably resulted in higher life expectancy, which in turn may have had its repercussions on public finance. However, the exact impact of health care spending on life expectancy growth in the Netherlands is difficult to pinpoint. Applying the estimates from published studies to the observed increase in health care spending in the Netherlands between 2000 and 2010 would imply that 0.3% to almost 50% (1.6 years) of the increase in life expectancy is caused by increasing health care spending. If the influence of health care spending on life expectancy is at the higher end of these estimates, increased health care spending will have had a clear impact on pension funds. After all, a one-year increase in life expectancy at retirement age increases pension liabilities by 3 to 4 percent. If we extrapolate these findings into the future, this would imply that additional investments in the health care sector may cause further increases in life expectancy. As the strength of the effect of health care expenditures on life expectancy is rather uncertain, strong policy recommendations are difficult to give. Given the age profile of mortality risk, gains in life expectancy through increased health care spending will probably be reached through decreasing mortality rates at higher ages. Increases in life expectancy at higher ages may create an additional demand for health care but also imply an increase in pension liabilities. Based on these consequences within and outside the health care sector, it is important that, when evaluating new medical technologies that are known to extend life, costs of increased life expectancy are included, but that is currently not done. If further research allows better quantification of the strength of the effect of health care spending on life expectancy, the role of such spending as a determinant of mortality could be acknowledged when making forecasts of life expectancy.

Abstract

Health care expenditures and life expectancy have both been rising in many countries, including in the Netherlands. However, it is unclear to what extent increased health care spending caused the increase in life expectancy. Establishing a causal link between health care expenditures and mortality is difficult for several reasons. In medicine, randomized clinical trials are the gold standard to demonstrate causality and thereby the effectiveness of clinical interventions. However, data from randomized trials are not available to estimate the influence of health care spending on life expectancy. As a result, researchers have tried a variety of methods and data sources to establish a causal link between health care spending and life expectancy. Our review of empirical studies revealed nonetheless that a causal influence of marginal increases in health care spending has been difficult to demonstrate in empirical research, given all methodological issues surrounding the estimates of empirical studies. We conclude therefore that, while it appears likely that increases in health care spending have contributed somewhat to the growth in life expectancy in Western countries, the strength of the effect remains uncertain and may differ between sectors. Also, the mechanisms underlying the causal relationship between health care spending and life expectancy are still unclear. For instance, both the role of specific medical technologies and that of health care reforms seem important in this context, but especially regarding the role of health care reforms sound evidence is lacking. Therefore, further research in this area, which would profit from new data sources and increased possibilities for data linkage, as well as further developments of the methods to exploit these, remain needed.

1. Introduction

Recent increases in health care expenditures in the Netherlands, possibly caused by health care system reforms, were accompanied by an increase in life expectancy (especially life expectancy at older ages), suggesting a causal relation between the two (Mackenbach et al. 2011). A central question in the Netspar theme 'Causes and consequences of rising life expectancy in the Netherlands' is whether recent increases in life expectancy are indeed caused by increased health care spending. In this Netspar panel paper, we will summarize the findings of studies that have tried to establish a causal link between health care expenditures and health outcomes as measured by mortality and/or life expectancy.

We will try to answer the following research question in this paper:

- Is there evidence that health care expenditures are a causal determinant of life expectancy?
- Along the way we will also address the following related research questions:
- What types of health care spending have affected life expectancy? For instance, is there evidence that increases in spending in specific health care sectors (e.g. hospital care) have affected mortality, or was it spending targeted at specific disease groups (e.g. cancer)?
- What is known about the effects of health care spending on particular subgroups? For instance, did health care spending mainly affect mortality of the young or instead of the old?
- Is there evidence that interventions at the macro level (e.g. health system reforms) that impact health care spending also impact life expectancy?

This paper is structured as follows. First, we will present some background describing the conceptual relations between health care spending and mortality. In this section we will first argue that an increase in health care spending does not necessarily lead to an increase in life expectancy. Second, we will describe the difficulties encountered in establishing a causal relation between health care spending and mortality. Third, we will give an overview of studies that have tried to establish a link between health care spending and life expectancy, and translate the findings of these studies to the Dutch context. The paper concludes with a summary of our findings and suggestions for future research.

2. Theoretical background

Medical care and mortality

Life expectancy has been on the rise in most Western countries since the nineteenth century. The question whether medical care has played an important role in this rise has been a topic of intense scientific debate (Nolte and McKee 2004). Until the 1950s it was assumed that medical care has contributed substantially to the observed mortality decrease, mainly through effective combating of infectious diseases. However, Thomas McKeown challenged this common wisdom. He published several studies in which he demonstrated that the decline in mortality of infectious diseases preceded the introduction of effective medical therapies for these diseases.[1] From this, McKeown concluded that medical care has not made a substantial contribution to the mortality decline since the middle of the nineteenth century until the 1950s. Although some of the conclusions drawn by McKeown have been questioned (especially his conclusion that improvements in longevity were mainly the result of improved living standards leading to better nutrition), the importance of his work should not be underestimated (Mackenbach 1996; Bunker 2001). An important lesson from the work of McKeown is that it cannot be automatically assumed that more medical care always leads to an increase in life expectancy.

Since the 1950s causes of death have changed from mainly infectious diseases to chronic diseases, and medical care has changed in response to this epidemiological transition (Cutler et al. 2006). Inspired by the work of McKeown, researchers have investigated whether causes of death that are amenable to

1 McKeown's work is summarized in his much cited book, 'The Role of Medicine – Dream, Mirage or Nemesis' (McKeown 1979).

medical care have declined since the 1950s (Nolte and McKee 2004; Mackenbach et al. 1988). The main conclusion from this line of research is that medical care has contributed to the increase in life expectancy in Western countries since the 1950s. Some studies have gone a step further. They have argued not only that medical care is an important cause of increased life expectancy, but also that the investments in medical care were good value for money (Meerding et al. 2007; Cutler et al. 2006; Cutler and McClellan 2001). Using published evidence on the effectiveness of specific preventive and curative interventions within the health care sector, these studies have tried to construct a counterfactual to estimate life expectancy in the absence of these interventions. This counterfactual situation involves the absence of medical curative care and/or of various forms of prevention, such as medication to lower blood pressure and cholesterol levels, vaccinations, and early detection of diseases (screening). Differences between observed life expectancy and counterfactual life expectancy were then related to the costs of the various interventions in order to assess whether the interventions offered value for money.

Cutler and McClellan (Cutler et al. 2006) estimated the costs and benefits of medical technology for five health conditions in the US by combining data from several sources. They concluded that 'the benefits from lower infant mortality and better treatment of heart attacks have been sufficiently great that they alone are about equal to the entire cost increase for medical care over time'. For the Netherlands, Meerding et al. (2007) combined historical data on incidence and mortality for infectious diseases, cancer, and cardiovascular disease with information about the year in which specific medical innovations were introduced to construct counterfactuals. Based on their analyses, they concluded that

medical care has contributed to approximately 50% of the seven-year increase in life expectancy since the 1950s. The yield per euro spent on health care, however, varied substantially from one disease group to another (from €3,100 spent per life year gained for cardiovascular diseases to €15,000 per life year gained for cancer).

Against the backdrop of this literature, it is very likely that medical care on balance has contributed to the high levels of life expectancy witnessed today in many countries. However, this in itself does not imply that marginal increases in health care spending will further increase life expectancy.

The benefits of increasing health care spending

Health care spending can be broadly defined as the amount of money spent by individuals and private and public organizations for health care and its various components such as surgeries, therapies and medication. Health care spending encompasses amounts related to different health care providers such as hospitals and general practitioners, but it also includes expenses related to providers of long-term care.[2]

At the societal level, the most important determinants of health care spending are GDP, medical technology, and health care system features (Koopmanschap et al. 2010). In the Netherlands, for instance, recent increases in health care spending were partly due to changes in the way health care providers were reimbursed (Van de Vijsel et al. 2011).

2 It is important to note that differences in health care expenditures between countries are partly caused by different definitions of health care. Sometimes health care facilities that exist in one country do not exist in other countries (e.g. homes for the elderly in the Netherlands). Furthermore, definitions of the health care system differ between countries: some facilities are considered part of the health care system in some countries, while they are excluded in others.

An increase in health care expenditures may be the result of an increase of health care volume and/or of the price of health care. Both mechanisms may positively impact life expectancy. An increase in the volume of health care may imply a higher coverage of medical care, a reduction of waiting lists, or that new effective treatments have been implemented. An increase in price may be the result of implementation of new (more expensive) effective technologies, but also of higher wages, which in turn may result in a more efficient delivery of health care. All these different mechanisms make clear that the effect of higher health care spending will be largely determined by the cause of the higher spending. Sudden changes in the growth of health care spending may be caused by reforms in the health care sector, and that may have differential effects on life expectancy, depending on the type of reform. One may hypothesize that an increase in health care spending resulting from a change to output-based financing of hospitals has a different effect on mortality compared to an increase in health care spending due to an expansion of long-term care facilities. For the purpose of this paper it is useful to distinguish between effects of health care spending on mortality at the micro level (e.g. through new medical technology) versus effects of health care spending on mortality at the macro level (e.g. through health system reforms).

The impact of health care spending on mortality has been studied extensively on a micro level for isolated medical interventions in strictly defined patient groups. Nowadays, in some countries, before new medical technologies (new drugs, diagnostic technologies etc.) will be reimbursed by insurers or adopted by health care providers, it must be demonstrated that these new technologies offer value for money (O'Donnell et al. 2009). To demonstrate such value for money, a cost effectiveness

analysis is usually conducted. In such cost effectiveness analysis, evidence regarding the effectiveness of, for instance, a new drug (mostly coming from randomized clinical trials) is combined with cost and quality-of-life data to estimate the costs and benefits of a well-defined intervention. Cost effectiveness is typically expressed as an incremental cost effectiveness ratio (ICER), the ratio of change in costs to the change in effects (Drummond et al. 2005). Costs refer to the resources used for the intervention, usually measured in monetary terms such as dollars or euros. The measure of effects depends on the intervention being considered. For life-saving interventions, effects are usually expressed in life years gained. Sometimes the effects are measured using quality-adjusted life years (QALY) or disability-adjusted life years (DALY); that also includes the impact of interventions on non-fatal health outcomes. Important characteristics of cost-effectiveness analyses are that they are conducted ex-ante on a micro level and that incremental costs and effects due to a single intervention are the central outcome measures. This contrasts with the empirical research discussed in this paper, where the average returns of health care spending (usually a mix of different technologies) in terms of life expectancy are estimated ex-post using mostly macro level (aggregated) data.

Even though evidence-based analyses of medicine and cost effectiveness have become more important over the years, they do not provide sufficient evidence that more health care spending does lead to an increase in life expectancy. There are several reasons for this, as follows:

1. Not all medical care is intended to reduce mortality. Rather, it may be intended to increase the quality of life or to reduce disabilities. For instance, in the Netherlands a large share of health care spending is on treatment of mental diseases which,

for a large part, are non-fatal (Slobbe et al. 2006; Poos et al. 2008). Therefore, if additional health care spending is mainly caused by expanding care for non-lethal diseases, this could possibly increase population health while life expectancy remains unaltered.

2. Wages in the health care sector may increase without causing any productivity gains (so-called Baumol's disease), thus leaving mortality unaffected (Pomp and Vujić 2008).
3. Not all medical care is based on solid scientific evidence, and expenditures can rise because of an increase in the use of non-effective procedures.
4. Even if there is evidence on medical interventions, findings from clinical trials do not always predict well how some medical interventions work in practice (Flather et al. 2006). Patients in clinical trials are often recruited using strict inclusion criteria (e.g. non-smoking, no co-morbidities) and do not resemble real life populations. In daily practice, interventions are offered to populations that differ from the patients included in a trial (broader indication areas, other age categories, persons with co-morbidity). Furthermore, adherence to treatment protocols is usually much better in clinical trials than in daily practice.
5. Even if effective life-prolonging interventions are implemented in practice, it can occur that other effective life-prolonging interventions are displaced. If the displaced activities were more cost-effective than the newly implemented interventions, an increase in health care spending may even result in increased mortality (McCabe et al. 2008).

Health care expenditures and mortality: methodological issues

Although health care spending and life expectancy have generally both been on the rise in Western countries in the past several

decades (OECD 2006), it is difficult to isolate the contribution of medical care to this increasing life expectancy. Given the impossibility of randomized controlled clinical trials, establishing a causal link between health care spending and life expectancy is difficult for several reasons. First, life expectancy is determined by many factors varying over time and place, which makes it hard to adjust for all the potential external influences on mortality other than medical care. Second, there may be time lags between health care spending and its effects on health. Finally, there

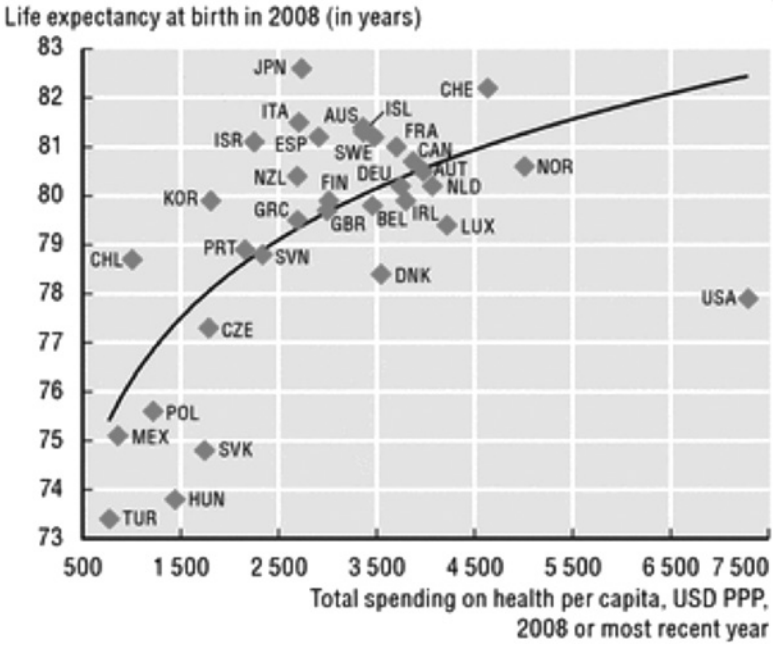

Figure 1: Life expectancy at birth plotted as a function of total health care spending per capita in 2008.

Source: OECD (2010), OECD Health Data 2010, OECD Publishing, Paris (*www.oecd.org/health/healthdata*).

is the issue of reverse causality since increased longevity may create additional health care demand as people live longer. In this section we will briefly discuss these issues. This will help to understand better the methodological approaches and findings of the empirical studies in the next chapter.[3]

Confounders

In general, it is observed that countries with higher health care spending also have a higher life expectancy.

Figure 1 clearly demonstrates a correlation between health care spending and life expectancy. However, this correlation does not necessarily imply a causal relationship running from health care spending to life expectancy. As life expectancy is determined by many factors, one would have to correct for many confounders including life style factors (e.g. smoking) and environmental factors (e.g. air pollution) to assess the role of health care spending. An important confounder within the context of the impact of health care spending on life expectancy is GDP. It has long been known in the field of health economics that GDP is the most important determinant of macro-level health care spending (Gerdtham and Jönsson 2000). Given the high correlation between GDP and health care spending, we would get a similar pattern as in Figure 1 when plotting gross national product (GDP) on the x-axis instead of health care spending. It has been argued that a higher GDP in itself is an important determinant of life expectancy, independent of its effect through increased

3 Counterfactual studies, mentioned at the beginning of this chapter, do not estimate the impact of health care spending directly but indirectly, using data from other studies or expert knowledge. Therefore, issues related to confounders, reverse causality, and time lags were not addressed in these counterfactual studies, but only in the studies used to construct the counterfactuals.

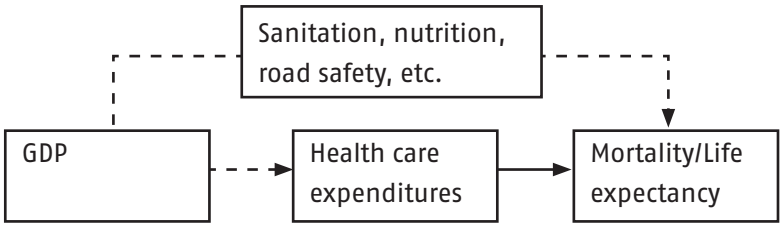

Figure 2: Simple causal chain from GDP to mortality

health care spending (McKeown 1979). As discussed, reductions in mortality which took place from the second half of the 19th century onwards were, for the most part, the result of a healthier living environment (improved drinking water facilities, drains, and sewers), a better hygiene, and diet. To better understand the role of GDP as confounder, Figure 2 displays a simple causal chain from GDP to mortality.

GDP impacts many other determinants of mortality besides health care spending. A higher GDP may imply better nutrition, more extensive educational opportunities, better road safety, ability to buy better cars, etc. For our purposes, we are only interested in the solid black arrow in Figure 2. However, this can only be estimated if one properly adjusts for the other arrows in Figure 2. GDP is obviously not the only confounder. For instance, life-style habits (especially smoking) are important confounders as well (even though not necessarily related to GPD). Furthermore, the relevant confounders also depend on the level of aggregation of the data. For data at population level, GDP is of course an important confounder. However, for studies using regional data GDP is less relevant, and other confounders may then become more important.

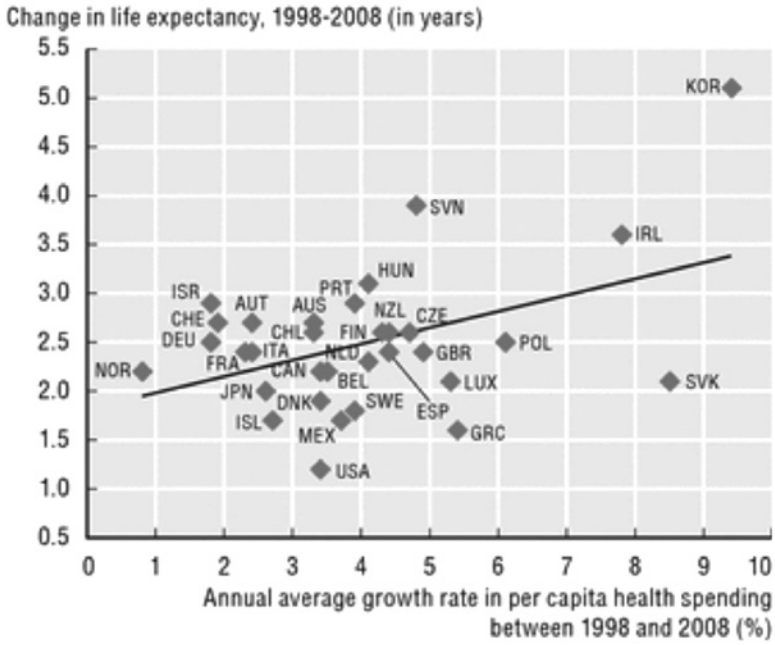

Figure 3: Changes in life expectancy at birth between 1998 and 2008 plotted as a function of changes in total health care spending per capita.

Source: OECD (2010), OECD Health Data 2010, OECD Publishing, Paris (*www.oecd.org/health/healthdata)*

Time lags

In Figure 1, we saw a strong relation between health care spending and life expectancy. The graph plots current health care spending against current mortality. However, current mortality rates are probably also influenced by health care spending in the past. While some medical interventions have an immediate effect (e.g. better trauma care, blood pressure medication), other medical interventions only influence mortality in the longer run.

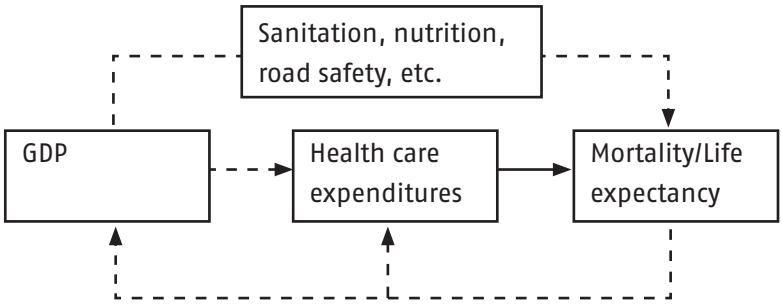

Figure 4: Causal chain running from GDP to mortality and back

Examples are screening for cancer (Tabar et al. 2003), which has consequences in the distant future, but also diabetes treatment (Malmberg 1997). Figure 3 plots changes in life expectancy against changes in health care spending. It suggests that countries with a larger increase in health care spending also witnessed a sharper increase in life expectancy. This suggests that there are immediate causal effects of health care spending on mortality.

Reverse causality

While this panel paper focuses on the causal influence of health care spending on life expectancy, a large body of research within health economics has focused on the reverse causal mechanism: the causal influence of life expectancy on health care spending. Many studies have investigated whether the demand for health care increases with increasing longevity. In these studies, health care spending was the dependent variable instead of an explanatory variable. Figure 4 extends Figure 2 by allowing for reverse causality.

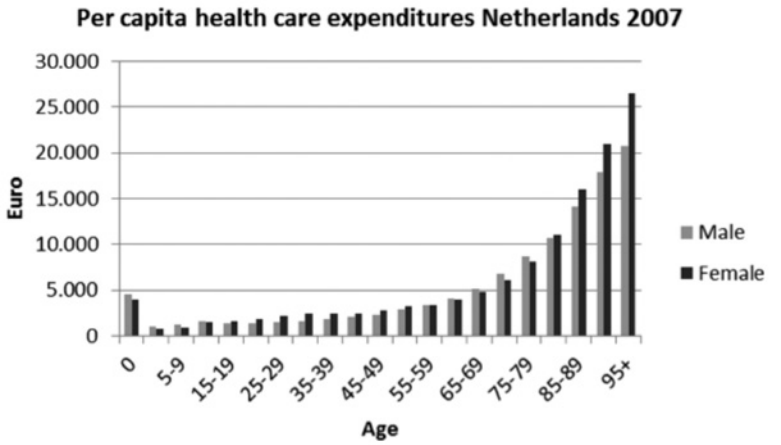

Figure 5: Per capita health care expenditures by gender and age in the Netherlands in 2007 according to the definition of health care spending of the System of Health Accounts

Source: RIVM Costs of Illness

Reverse causality running from mortality to health care spending can follow two paths. First, there is an indirect path, by which an increase in life expectancy may increase GDP and thereby increase health care spending. It has been argued that improvements in life expectancy have led to economic growth (Bhargava et al. 2001; Swift 2010), which may have caused an increase in health care expenditures since economic growth is an important determinant of health care spending. Second, there is a direct link in the sense that if people live longer, they are likely to need health care for a longer period of time. A higher life expectancy means more people surviving (either healthy or with disease), getting older, and being exposed to other diseases (substitute morbidity), which leads to need for cure and care. This second path has been much studied within the context of the

economic consequences of population aging. To understand the rationale of why so much research is carried out on the effects of aging on health care expenditures, Figure 5 displays per capita health care expenditures for different age categories in the Netherlands.

In Figure 5, we can see that health care spending strongly increases with age. This figure therefore suggests that an increase in life expectancy leads to an increase in health care spending. However, although the growing number of elderly people enlarges the group of individuals in need of health care, the question whether longevity gains increase health care spending has been subject to debate (Zweifel et al. 1999; Salas and Raftery 2001; Getzen 2001; Seshamani and Gray 2004; Felder et al. 2009; Van Baal and Wong 2012). Zweifel et al. (1999) argued that differences in health care spending between individuals can be better explained by time to death (TTD) than time since birth (age). In their view, the steep increase in health care spending by age is mainly the result of the steep increase in mortality with age. With respect to the question whether increased longevity increases health care spending, the TTD theory has strong implications. If we account for the fact that individual health care consumption concentrates during the period before death, an increase in life expectancy does not strongly increase the demand for health care as most of health care demand is merely postponed (Payne et al. 2007). In this sense the strength of the reverse causality effect may be weaker than originally thought, even though it is not absent as, for instance, long-term care in contrast with cure still shows a strong relation with age, when taking into account time to death (Koopmanschap et al. 2010).

3. Review of empirical studies

In the previous section, we described three issues that arise when one wants to investigate the causal influence of health care expenditures on mortality/life expectancy. First, there are many other determinants of mortality besides health care expenditures that have to be considered. Second, there may be a time lag between health care spending and its effects on mortality. Finally, there is the issue of reverse causality in the sense that current health care spending is to some extent influenced by current levels of mortality as well as past levels of mortality. Although some methodological issues depend on the type of data used, there are some general issues that are worth mentioning in the context of this paper. These issues are clearly discussed by Gravelle and Backhouse (1987). Primarily, to deal with confounders and reverse causality, they proposed to first specify a health production function based on theory. They demonstrate that specifying a production function allows modeling of the different causal paths that govern the relation between health care spending and mortality. As the data in this area of research do not come from trials which were set up with pre-specified hypotheses, Gravelle and Backhouse argue that conducting statistical analyses without first specifying a theoretical model "leads to a theoretical search for measures demonstrating statistically 'significant' associations with health outcomes."

In this section, we will summarize the findings of empirical studies that have tried to estimate the causal influence of health care spending on life expectancy and/or mortality. As a starting point, we have taken the review studies by Nolte and McKee (2004), Nixon and Ulmann (2006) and Grootendorst, Piérard, and Shim (2009). From these review studies, we will only discuss the

studies that included health care spending as an independent variable. Within the context of this paper, we will focus exclusively on health care spending, which is the product of the volume and the price of care. Economic as well as medical journals were searched for studies that are more recent. We will subdivide this chapter on the empirical findings into sections depending on the type of methods and data used. We will start by discussing studies that have used data aggregated at country level, in order to investigate whether there is a relation between life expectancy/mortality and health care spending after correcting for various confounders. After that, we will discuss studies exploiting regional variations in health care spending and mortality within countries to estimate the effect of health care spending. Then we will describe a study that has used individual level data. In these sections, we will where possible translate the findings of the studies to the Dutch context.

Cross-country comparisons

In cross-country studies, indicators of mortality (e.g. life expectancy at birth, infant mortality, and/or causes of mortality amenable to health care) are regressed on a number of explanatory variables including health care spending. An important caveat of using cross-country data relates to the measurement of health care spending. Besides differences in what constitutes health care, there are problems in trying to convert health expenditures into a common currency. Some studies have used Purchasing Power Parities (PPP) for GDP to accomplish this, while other studies have used PPPs that are specific to health care. However, it has been argued that differences in inflation between the health care sector and other sectors are (at least partly) amenable to health policy and should therefore not be

corrected for. The studies used either data coming from a single year or from multiple years (also called panel data or longitudinal data). Compared to a single cross section of different countries, panel/longitudinal data offer richer information, but they also pose additional methodological challenges. Particularly, statistical issues associated with time series such as serial correlation should be adequately dealt with.

Total health care spending

Most studies involving cross-country data have used data from OECD countries, where health care spending is measured according to the System of Health Accounts definition. This definition of health care spending encompasses hospital care, pharmaceuticals, general practitioners, and long-term care (Orosz and Morgan 2004). Table 1 displays an overview of studies at country level that have used per capita health care spending (according to the System of Health Accounts) as predictor variable and mortality or life expectancy as outcome variable. To bring the results of these studies down to a common denominator, we translated the results of each study to the Dutch context. That meant taking the changes in per capita health care spending in the Netherlands between 2000 to 2010 (a 40% increase from roughly €3,700 to €5,300, adjusted for inflation and expressed in 2010 prices) and applying the empirical estimates of the studies to estimate their contribution to the observed increase in life expectancy in the Netherlands. Dutch life expectancy at birth increased from 75.5 to 78.8 years for men and from 80.6 to 82.7 years for women between 2000 and 2010. The changes in life expectancy resulting from the increase in health care spending, estimated in this way, are displayed in the last column.

Table 1: Summary of findings from empirical studies using panel data from different countries with health care expenditures as independent variable

Study & Data	Data	Outcome measures	Confounding variables included
Wolfe and Gabay (1987)	22 OECD countries for three years: 1960, 1970, and 1980.	LE at birth; LE at age 60; infant mortality rate; prenatal mortality rate.	GDP; butter consumption; road accidents; liver cirrhosis (female and male); tobacco consumption; employment in safe and risky industry.
Hitiris and Posnett (1992)	Annual time-series data on 20 OECD countries covering the 1960–1987 period.	Crude mortality rates.	GDP per capita; percentage 65+.
Elola, et al. (1995)	Cross-sectional data on 17 Western European countries in 1990 or 1991.	LE at birth; life years lost; infant mortality rate.	GDP per capita; dummy variable of health care system; percentage of population covered by health care system; Gini coefficient.
Or (2000)	Annual time-series data on 21 OECD countries over the 1970–1992 period.	Premature mortality; life years lost	GDP per capita; share of white-collar workers in total work force; NOx emissions per capita; consumption of alcohol; consumption of tobacco per capita; fat (butter) consumption per capita; sugar consumption per capita.
Berger and Messer (2002)	Annual time-series on 20 OECD countries over the 1960–1992 period.	Overall mortality rate per 1000 inhabitants.	GDP; % 65+; tobacco, alcohol & animal fat consumption; female labor force participation; % higher education; Gini coefficient; % eligible for in-patient care benefits; % eligible for ambulatory care benefits under a public scheme.
Nixon and Ulmann (2006)	Annual time-series data on 15 EU countries over the 1980–1995 period.	LE at birth; infant mortality.	Number of physicians, hospital beds; patient admission rate; average patient length-of-stay; population coverage of health care system; unemployment rate; alcohol & tobacco consumption; several nutritional variables; environmental pollution.
Heijink et al. (2012)	Annual time-series on 14 OECD countries over the 1996–2006 period.	Total avoidable mortality per 100,000 inhabitants	Age structure; mortality not amenable to health care; GDP; education; unemployment rate; alcohol and tobacco consumption

(health care expenditures according to the 'system of health accounts' definition)

Main findings	How would life expectancy have changed in the Netherlands between 2000 and 2010 based on estimated effect of health care spending?
Increase in medical spending leads to a significant improvement in female life expectancy. Other indicators of mortality were not significantly related to health care spending (HCE).	0.01 year increase in LE for men (0.3% of the observed increase in the Netherlands); 0.2 year increase in LE for women (8.7% of the observed increase in the Netherlands)
Health care spending significantly decreases crude mortality rates. A 10% increase in HCE decreases crude mortality rates by 0.8%.	0.6 year increase in LE for men (17.2% of the observed increase in the Netherlands); 0.3 year increase in LE for women (13.6% of the observed increase in the Netherlands)
Only infant mortality was significantly negatively related to health care spending. Other indicators of mortality were not significantly related to HCE. A 10% increase in HCE decreases infant mortality rates by 2.6%.	0.1 year increase in LE for men (1.8% of the observed increase in the Netherlands); 0.1 year increase in LE for women (3.0% of the observed increase in the Netherlands)
Heath spending was only significantly related to premature mortality for women. A 10% increase in HCE decreases premature mortality for women by 1.8%.	For this study it was not possible to translate findings to the Dutch context as it was not clear from the paper how premature mortality was calculated.
Health care spending has a significant negative effect on overall mortality. A 10% increase in HCE decreases overall mortality rates by 1.3%.	0.9 year increase in LE for men (27.5% of the observed increase in the Netherlands) 0.5 year increase in LE for women (21.7% of the observed increase in the Netherlands)
Health care spending has a positive impact on both male and female LE at birth, and negative impact on infant mortality rate. A 1% increase in health care spending increases life expectancy at birth by 0.02% for both males and females.	0.7 year increase in LE for men (22.1% of the observed increase in the Netherlands) 0.8 year increase in LE for women (35.8% of the observed increase in the Netherlands)
A 1% increase in health care spending decreased avoidable mortality by 0.11%.	0.3 year increase in LE for men (8.0% of the observed increase in the Netherlands) 0.3 year increase in LE for women (13.9% of the observed increase in the Netherlands)

From Table 1 we can see that most studies found a significant effect of total health care spending on mortality or life expectancy. The weakest effects were found in the study by Elola et al., who used only one cross-section of data. Results from the other studies, which used data from multiple years, indicate that changes in health care spending are associated with changes in life expectancy even when adjusted for confounders. The last column of the table displays estimates of how much life expectancy would have increased if the study findings were applied to the observed 40% increase in health care spending between 2000 and 2010 in the Netherlands. From this column we can see that there is a wide variation in the estimated effect of health care spending on life expectancy, ranging from 0.3% to 35.8%. This corresponds to an average cost effectiveness of the increase in health care spending ranging from €167,000 to €2,000 per life year gained. It should be noted that in most studies described in Table 1 only contemporaneous effects of health care spending on mortality were estimated. Only Heijink et al. estimated lagged effects of health care spending on mortality and found that lagged health care spending decreased mortality amenable to health care (Heijink et al. 2012). Furthermore, in none of these studies is the issue of reverse causality addressed; sometimes it is not even mentioned. This implies that the effect of health care spending on mortality may be overestimated. An obvious limitation of all studies is that adjustments were made only for observable confounders or country-specific time-invariant unobservable confounders in case of panel data. Finally, in most studies no explicit theoretical model was formulated to inform the empirical estimation strategy.

A study that did not use OECD data on total health care spending was the study by Barlow and Vissandjee (1999). They

used cross-sectional data on 77 countries for the year 1990 and regressed life expectancy at birth on total per capita health care spending (data on health care spending coming from various sources) while controlling for various confounders (daily intake of animal products, proportion of population with access to safe water, percentage of literate adults, percentage of population living in tropics). This study did not find any effect of health care spending on life expectancy.

Pharmaceutical expenditures

Two studies using country level data from OECD countries focused on pharmaceutical spending. Both found pharmaceutical spending to be positively related to life expectancy. Miller and Frech (2002) used cross-sectional data on 18 OECD countries, mostly from the year 1998 (some data collected was from 1990). They regressed life expectancy at birth and at ages 40 and 60 on pharmaceutical spending, while correcting for various confounders (GDP per capita, percentage of smokers, alcohol consumption, obesity). They found that pharmaceutical spending has a significant impact on most health outcomes. A 10% increase in pharmaceutical spending was found to increase life expectancy at age 60 by 0.6%. Shaw et al. (2002) used cross-sectional data on 19 OECD countries from 1997. They regressed life expectancy at ages 40, 60 and 65 on both current and delayed pharmaceutical spending while controlling for various confounders (e.g. GDP, alcohol & tobacco consumption). They found that both current and delayed pharmaceutical spending has a significant effect on life expectancy at age 40, 60 and 65. In this study a 10% increase in pharmaceutical spending was found to increase life expectancy at age 65 by 0.31%. In both studies no tests or sensitivity analyses were conducted to address reverse causality.

If we apply the estimates of these two studies to the Dutch context, life expectancy would have risen by approximately 0.2 to 0.4 years between 2000 and 2010 as a result of an increase in pharmaceutical spending of only €120 per capita. This would suggest that the increase in pharmaceutical spending was extremely cost-effective since the amount paid per life year gained is less than €1,000.

Health care reforms

Although health systems differ in many respects between countries, only few studies have tried to assess the impact of health care reforms on life expectancy. An important reason for this is the difficulties in characterizing health systems in ways that are traceable to regression analysis. This is because these systems often combine many differing forms of provision and financing, i.e. no country fits perfectly into just one of the categories (Gerdtham and Jönsson 2000). Of the papers that have tried to estimate the impact of health care reforms, outcomes were mostly restricted to measures of health care output and did not include measures of mortality or life expectancy. However, Moreno-Serra and Wagstaff recently studied the impact of hospital payment reforms on health care outcomes in 28 countries in Europe and Central Asia over a longer time period (Moreno-Serra and Wagstaff 2010). They estimated the impact of three major hospital payment methods: global budget, fee-for-service (FFS), and the patient based payment (PBP) system. They found that FFS and PBP both increased health care spending compared to a global budget. Of the two methods, only PBP appeared to have any beneficial effect on amenable mortality, but these results were very sensitive to model specification. For the Netherlands, these results seem to have little relevance as the reform from a global budget to fee-

for-service coincided with the increase in life expectancy (Van de Vijsel et al. 2011).

Studies using regional data

Studies using regional data have obvious advantages as, within a country, differences in terms of health care provision (and possibly also health) can expected to be smaller than between countries, plus there are fewer conversion problems associated with health care spending measurement. Studies using data from Canada and the UK have been published that have exploited regional variation in health and health care to investigate the effect of health care spending on mortality.

Total health care and pharmaceutical expenditures

Two studies used time series data from different regions in Canada (Cremieux et al. 2005; Cremieux et al. 1999). One study (Cremieux et al. 2005) focused on pharmaceutical spending, while the other study (Cremieux et al. 1999) focused on total health care spending. In the latter paper, on total health care spending, data from 10 provinces in Canada covering the 1978–1992 period were used. Infant mortality and life expectancy were regressed on public and private health care spending per capita while controlling for per capita number of physicians, GDP per capita, population density, unemployment and poverty rate, and alcohol and tobacco consumption. Province-specific dummy variables were included to capture differences between regions. Effects of health care spending were found to be significant for all outcome measures. A 10% increase in health care spending was estimated to increase male life expectancy by 0.05% and female life expectancy by 0.024%. Applying these estimates to the Netherlands suggests that, of the increase in male life expectancy by 1.6 years between

2000 and 2010, 50% would have been the result of increased health care spending, implying an average cost of €1,000 per life year gained. For women, the corresponding numbers would be 0.8 years (39%) and €1,900 per life year gained.

In the paper on pharmaceutical expenditures, cross-sectional time-series data for Canadian provinces from the 1975-1998 period were used. Infant mortality and life expectancy at birth and age 65 were regressed on public drug spending per capita, private drug spending per capita, and non-drug health care spending per capita, while controlling for GDP per capita, population density, poverty rate, alcohol consumption, and tobacco consumption. Public and private drug spending were found to have a significant impact on most mortality indicators. A 10% increase in public drug spending per capita was estimated to increase both male and female life expectancy at birth by 0.1%. Applying these estimates to the Netherlands, this suggests that an increase in pharmaceutical spending by €120 would have led to an increase of male/female life expectancy by 0.2/0.3 years between 2000 and 2010. Again, this would suggest that the increase in pharmaceutical spending was extremely cost-effective as the amount paid per life year gained is below €1,000. Total non-drug health care spending per capita had a significant negative effect on male mortality, but not on female mortality. In both papers by Cremieux et al. only contemporaneous effects of health care spending on mortality were estimated. No tests or sensitivity analyses were conducted to address reverse causality.

Disease specific health care expenditures

Martin et al. published two studies (2008 and 2012) in which they used program budgeting data from about 300 Primary Care Trusts (PCT) in the UK to estimate the influence of health care spending

for different programs of care on mortality (programs of care refer to care for different disease groups). Each PCT covers a different geographical region within the UK; its task to allocate an annual lump sum budget allocated by the national ministry to different programs of care within its region. The models that Martin & al. estimate are derived from a theoretical model of the budgetary problem faced by a PCT. The theoretical model assumes that the PCT allocates this budget across health care programs to maximize a social welfare function. Using instrumental variable techniques to control for unobservable confounders, they estimated that costs per life year gained by health care programs range from £7,279 for circulatory problems, £13,931 for cancer, and £26,453 for diabetes. Cause-specific mortality under the age of 75 was used to calculate years of life lost, which were used as outcome variables in this study. Lagged influences were not considered in this study, and only instantaneous effects of health care spending on mortality were estimated. Using Dutch illness cost data from 2003 and 2007 (Slobbe et al. 2006; Poos et al. 2008), we translated the findings from these studies to the Dutch context. In this period per capita health care spending on cancer increased from €150 to €210 and for cardiovascular disease from €330 to €420 (all expressed in 2007 price level). This would translate to an increase in life expectancy of about 0.4 years due to increased spending on cardiovascular disease and 0.6 years due to increased spending on cancer.

Health care reforms

Regional data from the UK have also been used to investigate the consequences of introducing competition between hospitals in 2006. Two studies found that regions in which competition between hospitals was more fierce had slightly lower mortality without higher hospital expenditures (Cooper et al. 2011; Gaynor

et al. 2010). As the English system differs in many ways from the Dutch system it is not clear how to translate these findings to the Dutch context. They do, however, support the hypothesis that competition in health care may have beneficial effects on health.

Studies using individual level data

No studies are available that used individual-level data to investigate whether increased health care spending increases individual life expectancy. However, using individual level data, a few studies have tried to assess the costs and benefits (in terms of mortality) of an isolated technology. As mentioned in the previous chapter, the effectiveness (and sometimes also the costs) of new technology is usually established in clinical trials. However, as both costs and effects of a new technology may in real life differ from a trial, also the cost effectiveness of new technologies may be different in real life. As a consequence, the effect of introducing a new technology that increases health care spending does not automatically mirror the effects found in trials. An important study by David Cutler evaluated the costs and benefits of revascularization after a heart attack in the late 1980s (Cutler 2007). He used individual data from the US, including medical records and insurance claims of persons who were admitted to a hospital with a heart attack in the 1986–1988 period. Cutler separately related the patients' mortality and cumulative medical spending over a period of 17 years to a set of demographic and health control variables and a dummy variable, indicating whether the patient received a revascularization procedure or not. Instrumental variable techniques were used to correct for confounders. Cutler estimated that the greater survival for patients receiving revascularization translates into 1.1 years of additional life expectancy at an average cost of about $38,000. Thus, the

cost per year of life is $33,246. Major strengths of this research are the use of individual level data and the use of a good instrument (differential distance to a hospital) and the long follow-up period. This allowed addressing all the issues mentioned in the previous chapter. Findings from this study are relevant for the Dutch situation as survival after myocardial infarction has also improved in the Netherlands, partly due to improvements in revascularization (Nauta et al. 2011). However, it is not entirely clear how changes in clinical practice as described by Nauta et al. have influenced health care spending in the Netherlands.

4. Conclusions & discussion

Conclusions

While it is obvious that health care spending exerts a positive influence on life expectancy, it is less obvious whether marginal increases in health care spending have resulted in increased life expectancy. If we return to the research questions that we formulated in the introduction, we can conclude the following. Notwithstanding all methodology issues surrounding the estimates of empirical studies, it appears likely that increases in health care spending have contributed to the growth of life expectancy in Western countries. However, the strength of the effect remains uncertain, and the differences between sectors and mechanisms are unclear. Most studies looked at increases in overall health care spending and did not differentiate between the effects of different health care providers. Some studies focused on pharmaceutical spending and found quite strong effects on life expectancy, given the relatively low percentage of overall health care spending that is spent on pharmaceuticals. None of the studies focused on particular subgroups. In general, however, stronger effects of health care spending on mortality were found for newborns and the elderly, which is not that surprising given that mortality and health care consumption are highest in these groups. There is evidence that interventions at the micro level, such as the availability of medical technology, has exerted a positive influence on life expectancy. For instance, there is strong evidence that treatments for cardiovascular disease have contributed to the growth in life expectancy. However, the evidence base for a link between macro level interventions (such as health care system reforms) and life expectancy is weak.

Our review revealed that a causal influence of marginal increases in health care spending has been difficult to demonstrate in empirical research. Randomized controlled clinical trials are unsuited for estimating the influence of health care spending on life expectancy. As a result, researchers have tried out a variety of methods and data sources to attempt to establish a causal link between health care spending and life expectancy. Many studies used data aggregated at country level from OECD countries. In these studies it is difficult to disentangle the effect of health care spending from the effects of confounders such as GDP on life expectancy or mortality. This was especially the case for studies that used cross-sectional data from a single year. Studies using country level panel data generally showed that there health care spending has a positive influence on life expectancy after controlling for several confounders. These findings were confirmed in studies using regional data from Canada and the UK. The review of empirical studies clearly demonstrated that it is difficult to demonstrate a causal influence of health care spending on life expectancy. Not a single study using country level or regional level data addressed all methodology issues (confounders, reverse causality, time lags). Only a study that used individual level data on revascularization (Cutler, 2007) addressed all methodology issues. However, as this study focused on an isolated technology (facilitating completeness), the relevance in terms of the effects of marginal health care spending are unclear. Our review also showed that some areas have hardly been researched. The question to what extent health systems influence mortality, for instance, is hardly researched.

Further research

More research is needed to identify the mechanisms by which health care spending influences mortality. For instance, the role of reforms in the Dutch health care system is unclear (Van de Vijsel et al. 2011). To allow for better evaluation, it is advisable to implement health system changes in a phased manner instead of changing the entire system simultaneously countrywide. Furthermore, no studies have been published yet that investigated the effects of marginal increases in health care spending using individual level data. Linking different datasets, including health surveys and hospital registries such as made possible by Statistics Netherlands, may facilitate this.

Relevance for the Netherlands

Based on our review of empirical studies, we conclude that it is likely that increased health care spending has contributed to the recent increase in life expectancy in the Netherlands. Applying the estimates from published studies to the observed increase in health care spending in the Netherlands between 2000 and 2010 would imply that 0.3% to almost 50% (1.6 years) of the increase in life expectancy may have been caused by increasing health care spending. An important reason for the wide range in such estimates is that they include all methodological problems highlighted in this paper. Therefore, these estimates should be handled with care. However, this wide range indicates that the counterfactual study by Meerding et al., which argued that 50% of the increase in life expectancy in the Netherlands since the 1950s can be attributed to medical care, should probably be interpreted as an upper bound.

Better understanding of the causes and (distributional) consequences of increased longevity remains essential, also in

relation to other sectors. If the influence of health care spending on life expectancy is at the higher end of these estimates, increased health care spending will have had a clear impact on pension funds, since a one-year increase in life expectancy at retirement age increases pension liabilities by 3 to 4% (De Waegenaere et al. 2012). Based on this consequence for the pension sector, it is important that any evaluation of new medical technologies addresses the costs and benefits of increased life expectancy (Meltzer 1997). Currently, this is not done as evaluation of new technologies only includes a limited set of cost categories (Brouwer et al. 2008). Not only pension payments (which involves transfer of welfare), but also additional consumption and production during gained life years should be addressed. Finally, if there is indeed a link between marginal increases in health care spending and increased life expectancy, then the role of health care spending as a determinant of mortality could be acknowledged when forecasting life expectancy.

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35 The influence of health care spending on life expectancy (2013)
Pieter van Baal, Parida Obulqasim, Werner Brouwer, Wilma Nusselder and Johan Mackenbach

Netspar

The influence of health care spending on life expectancy

Health care expenditures and life expectancy have both been rising in many countries, including in the Netherlands. However, it is unclear to what extent increased health care spending caused the increase in life expectancy. Researchers have tried a variety of methods and data sources to establish a causal link between health care spending and life expectancy. This Panel Paper by Pieter van Baal (EUR), Parida Obulqasim (EUR), Werner Brouwer (EUR), Wilma Nusselder (Erasmus MC) and Johan Mackenbach (Erasmus MC) reviews these methods and data sources in order to investigate whether there is a causal link or not.