Medical innovations and labor savings in health care

An exploratory study

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SAMENVATTING

Aanleiding

Door de vergrijzing doet de zorgsector een steeds groter beroep op de arbeidsmarkt. De komende jaren dreigen grote tekorten aan zorgpersoneel. Bij ongewijzigd beleid zou rond 2025 bijna 25% van de Nederlandse beroepsbevolking in de zorgsector moeten werken om aan de stijgende zorgvraag te voldoen. Dit is niet realistisch. Het is onmogelijk zo veel mensen voor een baan in de zorg te interesseren. Daarom is het van belang om maatregelen te nemen die de arbeidsproductiviteit in de zorgsector verhogen, zodat met minder personeel toch de benodigde zorg kan worden geleverd; bijvoorbeeld door een ruimere toepassing van medische innovaties. In het voorliggende rapport doen we een poging om meer inzicht te krijgen in het potentieel van arbeidsbesparende medische innovaties. Bijzondere aandacht gaat uit naar de inzet van arbeidsbesparende innovatieve geneesmiddelen.

Aanpak

Het onderzoek heeft een *explorerend* karakter. Gezien de ambitieuze doelstellingen van het project maken we gebruik van verschillende onderzoeksmethoden. Met een *economische* blik kijken we naar inzichten uit de medische wetenschap. Ten eerste is een uitgebreid literatuuronderzoek uitgevoerd om empirisch materiaal te verzamelen over arbeidsbesparende medische innovaties in de zorgsector, mede op basis van ervaringen in andere landen. Ten tweede zijn voor drie categorieën aandoeningen via een aanvullend literatuuronderzoek casestudies verricht:

- COPD/astma;
- cardiovasculaire aandoeningen;
- psychische aandoeningen.

De casestudies beperken zich tot farmaceutische innovaties. Ten derde vertalen we de resultaten van de casestudies naar de Nederlandse situatie om een *tentatieve* inschatting te maken van het potentieel voor arbeidsbesparende farmaceutische innovaties. De aandacht richt zich om praktische redenen op de ziekenhuiszorg. Ten slotte onderzoeken we de belemmeringen voor de inzet van arbeidsbesparende medische innovaties.

Innovatie en arbeidsproductiviteit

De literatuurstudie en de casestudies bevestigen dat innovaties van belang zijn voor de verhoging van de arbeidsproductiviteit in de zorg:

- Door de inzet van domotica kunnen in de ouderenzorg substantiële arbeidsbesparingen worden gerealiseerd, terwijl tegelijkertijd de kwaliteit van het leven van de patiënten wordt verbeterd.
- Telemedicine/E-health kan door ICT-toepassingen bijdragen aan een vermindering van het beroep op de zorg.
- De toepassing van innovatieve geneesmiddelen levert een bijdrage aan de verhoging van de arbeidsproductiviteit via een vermindering van het beroep op ziekenhuizen en andere zorgvoorzieningen, en verlaagt het ziekteverzuim.
- Medische procesinnovaties, zoals ketenzorg en disease management, vergroten de doelmatigheid van de zorg.
- De casestudies voor COPD/astma, cardiovasculaire aandoeningen en psychische aandoeningen geven aan dat het aantal opnamen in (psychiatrische) ziekenhuizen en de gemiddelde verpleegduur sterk kunnen worden teruggedrongen via de inzet van innovatieve geneesmiddelen

Kwantitatieve effecten voor drie casestudies

De drie geselecteerde categorieën aandoeningen gaan gepaard met een groot beroep op (psychiatrische) ziekenhuizen. In Nederland lijden in 2003 circa 675.000 mensen aan coronaire hartziekten en 179.000 mensen aan hartfalen. COPD en astma zijn respectievelijk goed voor 316.000 en 520.000 patiënten. Naar schatting lijden 60.000 à 80.000 mensen aan schizofrenie en 160.000 à 240.000 mensen aan bipolaire stoornissen. De geselecteerde aandoeningen veroorzaken in 2007 circa 166.000 opnamen in (psychiatrische) ziekenhuizen. Voor *tien innovatieve geneesmiddelen* binnen deze categorieën aandoeningen beschikken we over voldoende gegevens om de arbeidsbesparingen ten gevolge van de inzet van deze geneesmiddelen voor de geselecteerde aandoeningen te becijferen. In verband met de beschikbare gegevens beperken we ons tot de *bruto* besparingen op de intramurale zorg. In totaal heeft de toepassing van de tien geneesmiddelen in 2007 geleid tot een besparing van 4.900 personeelsleden (3,6%) in ziekenhuizen en 2.300 personeelsleden (7,4%) in psychiatrische ziekenhuizen. Ruim een kwart van deze besparingen heeft betrekking op verplegend en verzorgend personeel.

Op termijn kunnen de arbeidsbesparende effecten van de inzet van de tien innovatieve geneesmiddelen aanzienlijk groter zijn doordat het aantal patiënten toeneemt en doordat eventueel meer patiënten met de betreffende geneesmiddelen worden behandeld. Daarom zijn vier scenario's voor 2025 doorgerekend. In alle scenario's groeit het aantal opnamen in (psychiatrische) ziekenhuizen overeenkomstig de demografische ontwikkeling. In het laagste scenario blijft het aandeel patiënten dat met de tien geneesmidde-

len wordt behandeld constant op het huidige niveau, terwijl dit aandeel in het hoogste scenario jaarlijks met 1,5% stijgt. In de twee middenscenario's wordt respectievelijk een groei van 0,5% en 1,0% voorzien. De personele besparingen in (psychiatrische) ziekenhuizen lopen uiteen van 9.100 personeelsleden in het laagste scenario tot 11.900 in het hoogste scenario. De resultaten maken duidelijk dat de inzet van innovatieve geneesmiddelen een bijdrage kan leveren aan de vermindering van de personeelsinzet in de intramurale zorg en daarmee aan de vermindering van tekorten aan zorgpersoneel. Gezien de omvang van de toekomstige arbeidsmarktproblemen zullen echter ook andere beleidsinstrumenten moeten worden ingezet.

Institutionele belemmeringen

Het potentieel voor de inzet van arbeidsbesparende medische innovaties is groot. Dat betekent tegelijkertijd dat institutionele belemmeringen voor de efficiënte en effectieve inzet van deze innovaties moeten worden weggenomen. De inzet van innovatieve geneesmiddelen is bijvoorbeeld sterk gereguleerd, zodat het niet eenvoudig is om de vruchten van innovatie, zoals een verminderd beroep op het zorgpersoneel, te plukken. De belangrijkste belemmeringen zijn:

- schotten in de financiering binnen de Zorgverzekeringswet en tussen de Zorgverzekeringswet en de AWBZ;
- verkeerde prikkels in de financiering van de zorgverzekeraars;
- het proces van toelating en vergoeding van nieuwe behandelingen, geneesmiddelen en andere verstrekkingen.

Verder onderzoek

Onze explorerende studie is onvermijdelijk aan *beperkingen* onderhevig. De studie berust op een beperkt aantal geneesmiddelen en richt zich op drie categorieën aandoeningen. Daarnaast beperkt de analyse zich tot *bruto* besparingen in de intramurale zorg. Met eventuele personele besparingen en/of uitbreidingen in de extramurale zorg is in de analyse geen rekening gehouden. Deze beperkingen kunnen worden weggenomen in verder onderzoek. Dit moet zich naar onze mening richten op:

1. een verbreding van de onderzochte set van geneesmiddelen;
2. een uitbreiding van de empirische analyse met andere dan farmaceutische innovaties;
3. een analyse van de personele besparingen en/of uitbreidingen in de extramurale zorg.

EXECUTIVE SUMMARY

Introduction

Population ageing has a strong effect on the labor market in health care. In the coming years, substantial shortages of health care personnel are expected. Without changes in government policy, in 2025, almost 25% of the Dutch labor force needs to work in the health care sector to meet increasing demands for health care. This is not a realistic scenario; it is impossible that such a large number of workers will be interested in a job in health care. Therefore, it is important to take actions that increase labor productivity in health care; for example by using medical innovations. As a result, the same levels of care can be achieved using fewer personnel. In the current study, we attempt to gain more insight into the potential labor savings of medical innovations. In particular, we focus on the productivity-increasing effects of innovative pharmaceuticals.

Method

This study is based on *exploratory* research. Given our ambitious goals, we use several research methods. From an economic point of view, we reinterpret results of medical science. First, we give a review of the literature on medical innovations that increase labor productivity. We also take experiences from other countries into account. Second, we present case studies of three categories of diseases:

- COPD/asthma;
- Cardiovascular diseases;
- Mental disorders.

Within each disease category, we focus on recent pharmaceutical innovations. Third, given the results of the case studies, we *tentatively* calculate the effect of the innovative pharmaceuticals in terms of labor-savings for the Netherlands. Due to practical concerns, our analysis is restricted to hospital care. Finally, we study the institutional barriers in the utilization of labor-saving medical innovations.

Innovation and labor productivity

Our literature review and case studies confirm that innovations are important for increasing labor productivity in health care:

- Owing to domotics (home automation), in elderly care, substantial labor savings can be realized, while at the same time the quality of life of patients can be increased.
- Telemedicine (e-health) leads to a reduced demand of health care.

- Innovative pharmaceuticals contribute to the increase of labor productivity through a reduced utilization of hospitals and other health services. In addition, worker absenteeism is reduced.
- Process innovations such as integrated care and disease management increase the efficiency of health care.
- The analysis of the case studies (COPD/asthma, cardiovascular disease and mental disorders) shows that the number of hospital admissions and average length of stay in a hospital can be reduced as a consequence of the use of innovative pharmaceuticals.

Quantitative effects of three case studies

The three selected diseases currently have a high share of (mental) hospital admissions. In the Netherlands, in 2003, about 675,000 people suffer from coronary heart disease and 179,000 people suffer from heart failure. Moreover, there are 316,000 COPD patients and 520,000 asthma patients. About 60,000-80,000 people suffer from schizophrenia and 160,000-240,000 people suffer from bipolar disorder. These selected diseases are associated with a total of 166,000 (mental) hospital admissions. For these diseases we have sufficient data for *ten innovative pharmaceuticals* to calculate labor savings as a consequence of utilizing these pharmaceuticals. Because of lack of data for outpatient care, we focus on gross savings of inpatient hospital care. The use of the ten innovative pharmaceuticals leads to a *gross* saving of 4,900 labor years (3.6%) in hospitals and 2,300 labor years in mental hospitals (7.4%). More than a quarter of these savings involve nurses and caregivers.

In the future, the labor-saving effects of the ten innovative pharmaceuticals can be larger because the number of patients will increase substantially, and because more patients are treated with these pharmaceuticals. Therefore, we present four scenarios for the year 2025. In all scenarios the number of admissions to a (mental) hospital increases at the same rate as the demographic trend. In the lowest scenario, the share of patients treated with the innovative pharmaceuticals remains constant (at the level of 2007), whereas in the highest scenario, the share of pharmaceutical users increases with 1.5%. The middle scenarios are in-between with growth rates of 0.5% and 1.0%. Gross savings include 9,100 respectively 11,900 labor years of (mental) hospitals in the lowest and highest scenarios. These results show that the use of innovative pharmaceuticals can reduce the number of personnel working in inpatient care, and therefore can reduce shortages of medical personnel. However, given the magnitude of the problem, other policy measures are needed as well.

Institutional barriers

In potential, the labor-saving effects of medical innovations are substantial. This means that institutional barriers that hamper efficient and effective utilization of these medical innovations need to be removed. The utilization of innovative pharmaceuticals, for instance, is heavily regulated. To some extent that impedes full realization of benefits from innovation such as reduced workload of personnel in health care.

The main barriers are:

- Segmentation in the financing of the curative health sector (Zorgverzekeringswet) and between the curative and long term care (AWBZ) health sectors;
- Wrong incentives in the financing of the insurers;
- The process of authorization and reimbursement of new medical treatments, pharmaceuticals and other medical innovations.

Further research

This explorative study inevitably has some limitations. The study only includes ten innovative pharmaceuticals and three disease categories. In addition, we only calculated *gross* labor savings of inpatient care. Savings (or increases) in outpatient care were not taken into account. Further research is needed to overcome these limitations. The following improvements are important:

1. Inclusion of a larger sample of innovative pharmaceuticals;
2. An extension of the empirical analysis with other innovations than just pharmaceutical innovations;
3. An analysis of personnel savings and/or increases in outpatient care.

1 INTRODUCTION

1.1 Background

The combination of baby boom in the post-war period, the subsequent fall in fertility rates from the end of the 1960s, and the increase in life expectancy lead to ageing of population in most European countries. The Netherlands are no exception; although ageing is not as prevalent as in many other European countries such as Denmark, Sweden and Finland (see Appendix A for an overview of the ageing of the population of several European countries). In the Netherlands, the proportion of elderly people will be still relatively low until 2010, but will increase considerably between 2010 and 2025.

Population ageing has two effects on health care. First, as health care costs increase with age, an ageing population means rising health care expenditure. The Netherlands Bureau for Economic Policy Analysis (CPB) expects that health care costs will rise by 6.6% per year between 2008 and 2012. The second effect of population ageing on health care is on the labor market, with the health sector likely to face critical staff shortages in the future. In terms of employment, health care is already one of the two largest sectors in the economy in the Netherlands. Second, the increasing demand for health care due to population ageing and rising disease prevalence escalates the scarcity of health care labor force. In this view, population forecasts conclude that in the coming years a quarter of the overall Dutch labor force supply should be employed in the health care sector (Goudriaan et al., 2005). Taking also into account the ageing of the current health care personnel, nearly all current school graduates should strive for a job in the health care sector in order to tackle this challenge. This is not a realistic scenario. Another non-feasible scenario is to enlarge the workload of health care personnel, because any such scenario would endanger the quality of care delivered to patients.

Therefore, the Netherlands have to take policy measures to tackle forthcoming shortages in the health care sector and more specific in elderly care. The Council of Public Health and Health Care in the Netherlands (the Dutch abbreviation is RVZ) has suggested to the Dutch Ministry of Health an extensive set of policies that could help in countering labor shortcomings in the health care sector (RVZ, 2006). However, these policies are

mostly targeted to the demographic patterns of health care personnel and do not cover additional areas.

Health care innovations generally increase labor productivity (Berndt et al., 2000). For example, innovative pharmaceuticals lead, in most cases, to substantial welfare gains (Tsiachristas et al. 2008). Possibly, health care innovations can contribute to the solution of the increasing medical personnel shortages and lead to reduced workloads of medical personnel. The question we address in this paper is: Do medical innovations increase labor productivity in an ageing society? Innovation in health care is not only important for the health care sector itself but it also generates societal gains in other sectors of the economy. The latter form of gains is beyond the scope of this study. Therefore, they are just briefly discussed in this paper. We focus mainly on labor savings in health care.

The introduction and diffusion of innovative pharmaceuticals in the health care sector faces many obstacles. This also applies to other innovative interventions such as new diagnostic devices, new medical procedures, innovative technology and domotics. An example of an obstacle is the phenomenon of the "Chinese walls" that exists in the financing of health care, which weakens the interests of stakeholders to invest on health innovations. Unfortunately, this goes at the expense of health care quality. This is in contrast to the aim of the new Dutch health care system to stimulate that health insurers not only compete on price but also on quality. Another type of segmentation exists in the financing of inpatient and outpatient care. The contribution of innovative pharmaceuticals in keeping people out of hospitals or reducing hospital stay is hampered by the segmented financing of inpatient and outpatient care. Another example of an obstacle forms the health care market per se. Competition is the engine of productivity growth; this also applies to health care. In highly regulated health care systems, the diffusion of productivity-enhancing medical innovations is more limited than they should be. As a result, these obstacles lead to welfare loss for the population.

The Pharmaceutical Committee of the American Chamber of Commerce (AmCham) in the Netherlands considers the role of innovation in health care important. AmCham sees it as a challenge to bring together different stakeholders in order to remove any barriers that the introduction of innovative and cost-effective interventions in the health care sector faces. Therefore, AmCham has asked Aarts de Jong Wilms Goudriaan bv (APE) and Maastricht University to investigate the role and the potentials of labor-saving innovation in health care, to identify the existing barriers facing

these innovations, and address possible solutions to overcome them. The results of this research will be presented in the 9th Clingendael European Health Forum.

1.2 Research aim and objectives

The research focuses on the role and potentials of labor-saving and productivity-increasing innovations in health care, examines the factors which impede their usage, and identifies potential solutions to overcome them. The primary focus regarding productivity is the medical productivity (measured in increased medical outcomes). The increased productivity of patients/workers in other sectors of the economy (such as reduced worker absenteeism) is in our research of secondary importance. The main question addressed in our research is: What can innovative pharmaceuticals and other medical innovative interventions contribute to the increase of labor productivity in health care?

In order to achieve the aim of this research, the following sub-questions have been formulated:

- What potentials do innovative interventions, such as usage of innovative pharmaceuticals, have for increasing labor productivity in health care in an ageing society? How could these innovations tackle the increasing personnel shortages in the health care sector?
- In which parts of health care and for which diseases would innovative interventions have the highest effectiveness?
- Which factors impede the usage of innovative pharmaceuticals and other medical innovations in the Dutch health care sector, what are the incentives for innovation in the current health care setting, which potentials exist to stimulate innovation, what in particular is the role of competition and how can the interests of different stakeholders be aligned?
- How adequate is the current funding scheme of innovations in health care? What is the scope for additional funding of innovations by parties that are currently benefiting from innovations (for instance less worker absenteeism) but do not pay for the costs?

Innovative pharmaceuticals are the central concept in this research. However, in our opinion it is important to go further than just to examine innovative pharmaceuticals. For that reason, we consider other innovations as well, such as home automation and telemedicine. Moreover, labor-saving

and productivity-increasing innovations within health care have a central position in our research.

1.3 Approach and overview of the report

This study combines an economic focus with insights from medical science in a review of the literature and in brief empirical analyses. In view of the ambitious research questions of this research, we employ several research methods to achieve our aim. The research approach is presented in detail in Chapter 2. The research starts with an extensive literature review in order to find innovative pharmaceutical and technological interventions that increase productivity and save personnel. A summary of the literature is given in Chapter 3. Following, in Chapter 4, we present three case studies which emphasize the role and importance of innovation with respect to three selected disease categories: COPD and asthma, cardiovascular diseases, and mental disorders. For these three disease categories, several studies show reduced hospitalization rates, shortened length of stay in hospitals, or reduced resource utilizations as a result of the use of innovative pharmaceuticals. Based on these results, we give a quantitative estimation of labor-saving innovations in Chapter 5. In Chapter 6, we identify obstacles to the diffusion and utilization of innovations in health care. Chapter 7 concludes this study with recommendations and potential solutions to overcome several obstacles.

2 RESEARCH APPROACH

2.1 Introduction

In this study, we conduct a literature review in order to collect empirical evidence on labor-saving innovations in health care. The literature review is also used to select the disease categories discussed in the case studies in which a deeper analysis per disease is done. The collected relevant studies per selected disease are used to calculate *tentatively* the labor savings generated in health care by innovative pharmaceuticals. In advance, we note that there is only limited number of studies available providing empirical evidence on the labor-saving effects of pharmaceutical and other medical innovations in (inpatient) health care.

2.2 Literature review

We have searched the scientific literature extensively to find studies relevant to the productivity and personnel effects of medical innovations in health care. We also attempt to identify the obstacles to such innovations in the Dutch health care system as well as to highlight the role of competition and regulation in the diffusion of innovation. We further elaborate on the existing incentives in the health care sector and provide solutions to overcome obstacles in promoting the utilization of productivity-increasing and labor-saving medical innovations. Finally, we examine whether the current structure of inpatient and outpatient care impedes the utilization of pharmaceutical and other medical innovations.

In detail, PubMed/Medline, Cochrane Library, Google scholar, Econlit, Center for Evaluation of Value and Risk in Health, Pharmacoeconomics, Value in Health, International Journal of Technology Assessment in Health Care, were searched for studies relevant to three types of health outcome findings:

- Hospital admissions
- Hospital days
- Personnel savings

The period covered ranges from January 1995 to November 2008. Searches were based on combinations of the following keywords:

1. Those that indicate a focus on innovations in health care: "innovative" or "innovation";
2. Those for the various interventions: "medical technology", or "pharmaceutical" or "medicine" or "disease management" or "diagnostic equipment" or "medical process" or "domotics" or "e-health".
3. Keywords for health care resources: "admissions", or "hospitalization", or "personnel", or "resource utilization".

For the selection of suitable studies for the quantitative analysis, we use only the studies relevant to pharmaceuticals since the results for other medical interventions were not sufficient to be included in the analysis.

Exclusion criteria are no innovations, comment, letter, news, congress report, note, abstract only, and language other than English. The titles, bibliographic data and abstracts of the results of these searches were scanned for relevance based on the exclusion criteria. After applying the exclusion criteria mentioned above to the full text articles, the remaining studies are checked for completeness and quality. For each study selected with hospital admissions, personnel, or days as the outcome measure, a standardized list of items is recorded in a database.

All studies are classified according to the type of disease (e.g. COPD, cardiovascular disease, et cetera). For the first three disease categories for which we have the most available studies, a list of all innovative medicines introduced in the Dutch market after 1995 is constructed. The list is presented in Appendix B. Having this list, we replace the second cluster of search keywords (i.e. medical technology, et cetera) with the chemical names of innovative pharmaceuticals included in the list. Keeping the first and third clusters of search keywords unchanged we search the literature once more.

When more than two studies are found for the same medicine then we use two criteria to make a further selection. First of all, we prefer studies in which patients in the standard arm receive regular treatment (and *not* a placebo). Secondly, we prefer studies that are published in peer-reviewed journals (excluding posters and not yet published drafts). However, when there is only one study found for a medicine then these selection criteria are not applicable. If we find more than one suitable study for a given medicine, we compute an unweighted average of the outcome measure.

2.3 Case studies and empirical analysis

First, we select disease-categories which have a significant impact on health and well-being, have a high prevalence, and for which innovative interventions already exist for their treatment/care. The diseases that fulfill those criteria and are thus potentially interesting for this analysis are: COPD and asthma, cardiovascular diseases and mental disorders. In the case studies we discuss the prevalence and impact of the selected diseases mainly on the Dutch society and present suitable studies per disease to be included in our quantitative analysis.

Based on the findings of previous research steps we estimate the labor savings in Dutch health care that can be obtained from the utilization of innovative pharmaceuticals. The empirical analysis focuses on pharmaceutical products relevant to the selected diseases. Future research can use the results of our pilot study to provide concrete and robust quantitative estimations. The availability of suitable information plays an important role in our analysis. In any case, we estimate how much hospital personnel can be saved by the utilization of innovative medical interventions.

For the analysis, we collect studies of innovative pharmaceuticals from the literature that report results in effects on average length of stay in a (mental) hospital and/or admission to a (mental) hospital.[1] From every selected scientific study, we extract findings that are expressed in hospital admissions and/or length of stay regarding the effectiveness of the examined innovative pharmaceutical and the comparator treatment (usually current medicine or placebo). We combine this data with the hospital personnel that are utilized to produce a hospital day for every examined disease. Our main concern is to find the difference in hospital days of utilizing innovative medicines and current treatments. More details about the methodological process of the quantification analysis are presented in section 5.2.

[1] Given that we also include mental disorders in our analysis, we both study hospitals *and* mental hospitals.

3 MEDICAL INNOVATION AND LABOR PRODUCTIVITY

3.1 Introduction

In this chapter we present an overview of the findings derived from the literature review relevant to medical innovations and productivity savings.

Most analysts agree that medical innovation, whether in the form of new drugs, medical devices, diagnostic techniques, or procedures, has resulted in substantial improvements in both quality and length of life (Cutler et al., 2007). Innovation takes place by product innovation, where new pharmaceutical or new treatment is introduced and by process (or logistic) innovation where health care delivery is performed more efficiently. Medical innovation occurs at the institutional level (e.g. restructure of health care financing), operational level (restructure of ICT, patient logistics and management processes), and technological level (e.g. new treatment procedure and new pharmaceuticals) (Putters, et al., 2006). In this chapter, we deal with pharmaceutical, technological, and process innovations. For practical reasons, our empirical analysis in the next chapters is, however, limited to pharmaceutical innovation.

Medical innovation is often seen as a primary driver of increasing medical costs (Newhouse, 1998; Okunade and Murthy, 2002). However, these innovations affect health-care expenditure in various direct and indirect ways. The application of new drugs or procedures may increase costs in the short or medium run, but they may reduce costs in the long run when they help preventing more serious conditions from developing. They can also have dynamic effects as a result of expanded indications of use (Docteur and Hoxley, 2004). In general, overall cost increases do not imply that medical innovations are undesirable or wasteful. Medical innovation not only brings health benefits but also non-health benefits such as a reduction in worker absenteeism and increased labor productivity (Lichtenberg, 1996, 2001, 2002; Acharya and Keller, 2007). These benefits need to be compared to the costs of innovation before robust welfare statements can be made. Innovations that result in higher benefits than costs are by definition beneficial, whether or not it increases expenditures.

For the economy as a whole, a 10% increase in domestic R&D translates on average into about 1.5% higher productivity while at the same time,

the contribution of international technology transfer often far exceeds the effect of domestic R&D on productivity (Acharya and Keller, 2007). There is also strong empirical evidence on the presence of productivity spillovers in medical care. Medical innovation in one sector improves productivity in that sector while reducing productivity elsewhere (e.g. by attracting specialists), thereby reinforcing the tendency to adopt new medical technologies (Chandra and Staiger, 2004). However, the effects of innovation in health care productivity have not received the appropriate focus in the scientific community. In the following sections we provide some relevant studies obtained through our literature review.

3.2 Pharmaceutical innovation

Pharmaceutical innovation has contributed to both medical care cost increases and savings. However, as long as the benefits are larger than the costs, innovation is worth it in total, because it increases welfare. Only taking into account the direct effects of innovative pharmaceuticals on health care expenditures gives a short-sighted perspective. In this section, we discuss some benefits of pharmaceutical innovations that are related to labor savings within and outside the health care sector.

Lichtenberg has extensively investigated the effects of innovative pharmaceuticals in a bulk of studies. His estimates imply that use of pharmaceuticals potentially reduces costs in other medical sectors (Lichtenberg, 2006). In particular, he finds that an increase of 100 prescriptions is associated with 1.48 fewer hospital admissions, 16.3 fewer hospital days, and 3.36 fewer inpatient surgical procedures (Lichtenberg, 1996) and that a reduction in the age of drugs utilized reduces non-drug expenditure 7.2 times as much as it increases drug expenditure (Lichtenberg, 2002).

Lichtenberg also states that innovative pharmaceuticals have a positive effect on labor supply. R&D-driven technical progress (often embodied technical progress) has been the major source of increase in the output per hour worked. Pharmaceuticals are about three times as R&D-intensive as most other goods and services (Lichtenberg, 2001). People consuming newer drugs are significantly less likely to die and are significantly less likely to experience work-loss days than people consuming older drugs. Since disability to work increases steadily with age, an alternative way of stating this hypothesis is that use of newer pharmaceuticals reduces the rate of human capital depreciation (Lichtenberg, 2002). Clearly, reduced use of labor-intensive sectors such as inpatient care leads to personnel

savings. Lichtenberg (2007) calculates that spending an additional $Can per capita on drugs generates savings of 31 doctors and interns.

However, Lichtenberg's findings faced many reactions by other academics and generated public debates via scientific journals. The most well known opposition was an article by Zhang and Soumerai (2007) in which the findings of Lichtenberg (2006) on reductions in other medical sectors by innovative pharmaceuticals are questioned. The authors replicated Lichtenberg's analysis and reported that many methodological biases occurred in his analysis that resulted in overestimations of medical cost reductions attributed to the utilization of innovative medicines. In a responding article published in the same scientific journal, Lichtenberg (2007) counteracts their arguments by providing supportive evidence to his previous research.

In line with the debatable findings of Lichtenberg, Crémieux et al. (2007) found that increases in drug spending could be more than offset by decreases in other health care spending without affecting the health of the population. In particular they conclude that increasing drug spending by $Can 1.00 results to a decrease of hospital and physician spending by $Can 1.48 for males and $Can 1.05 for females (Crémieux et al., 2007). Similarly, Berndt et al. (2000) have estimated that the average costs of depression treatment were 20% lower by shifting from therapeutic to pharmaceutical treatment without reducing health outcomes. Furthermore, a study by Duggan and Evans (2005) estimated that medical innovation of HIV antiretroviral treatments resulted in 20 percentage units lower inpatient stay from 1994 till 2003. Annual inpatient spending fell by an even larger percentage from $7,125 to $3,510. In contrast, annual outpatient spending increased slightly while spending on prescription drugs tripled, driven primarily by the increased use of antiretroviral drugs and their high cost. Although average annual spending on prescription drugs increased by $8,000 over the period, total spending increased by just $4,800. Their cost per life year saved is $22,000 (Duggan and Evans, 2005).

Innovative pharmaceuticals can be expensive, but price controls may have undesirable side-effects. Santerre and Vernon (2005) highlighted that price control leads to lower R&D investments which consequently result to less social gains. In particular, they found that on a per drug basis the consumer opportunity cost of not imposing a (hypothetical) price control policy was approximately $1.1 billion. These opportunity costs appear to be very small when compared to the benefits from the additional pharmaceutical R&D attributed to absence of price controls. The reason is that the social gain of innovative pharmaceuticals can be considerable. The ques-

tion is who benefits from this social gain: the innovative companies or other stakeholders. In a 25 year retrospective analysis for the use of innovative classes of medicines in the U.S.A. for HIV/AIDS, Philipson and Jenna (2005) assessed a social benefit of US $1,330 billion compared to only US $62 billion for innovative companies. This is less than 5% of the estimated social gain (the remaining 95% is reaped by consumers). They concluded that despite the high annual costs of these drugs to patients, the low share of the social surplus[2] going to innovators raises concerns about advocating cost-effectiveness criteria that would further reduce this share, and hence further reduce incentives for innovation (Philipson and Jena, 2005). Similarly, recent research by Garrisson et al. (2007) on transtuzumab for breast cancer and Parvinen (2007) on schizophrenia medicines, broadly support the conclusion of Philipson and Jenna.

In summary: pharmaceutical innovation in health care has substantially positive effects on health and labor productivity, while it reduces average length of stay in hospitals, worker absenteeism and costs of other medical interventions. Taking into account that the composition of pharmaceutical innovation across diseases responds to both aging- and obesity-induced changes in the relative disease incidence (Bhattacharya and Packalen, 2008), pharmaceutical innovation could become a catalyst in the sustainability of the health care system in the shadow of rapid ageing and disease prevalence.

3.3 Medical devices innovation

3.3.1 Treatment substitution and treatment expansion

Technological innovation includes physical capital, such as magnetic resonance imaging, new procedures, such as coronary bypass grafting or renal dialysis, or a combination of new physical capital with new procedures such as telemedicine and domotics. Technological innovation brings benefits in addition to cost savings, such as increased quality of life, longevity, less absence from work, and increased labor productivity of the medical sector (Bunker, 2001; Bunker et al., 1994; Luce et al., 2006). An apparently puzzling finding is that innovative technology often decreases unit costs of production, but increases overall expenditure. Here, we take a

[2] Social surplus is the aggregation of consumer and producers or innovators surpluses. Consumer surplus occur when willingness-to-pay exceeds the price paid. Producer or innovator surplus is obtained when production costs are lower than the price charged.

closer look to a study that considers medical productivity in relation to technological innovation.

Cutler and Huckman (2003) study technological change in the treatment of heart attacks. Prior to the early 1980s, patients with severe coronary artery disease (CAD) would receive bypass surgery, which involves grafting an artery or vein around the occluded coronary artery. Those patients with mild CAD receive less costly medical management, which includes the use of thrombolytic drugs. Angioplasty, developed in the late 1970s, provided an intermediate treatment with cost and intensity levels that fell in between those of bypass surgery and medical management. Angioplasty involves the use of a balloon catheter to break up the blockage. Those patients with low-grade symptoms – who received thus far only medical management – now could receive angioplasty. Thus, *treatment expansion* occurred – the new technology resulted in more intensive treatment of patients with low-grade symptoms. Despite its lower unit cost, due to treatment expansion, angioplasty raised total costs in the initial years of its diffusion. However, due to learning and improvements of the treatment over time, angioplasty began to be used on increasingly severe cases that were previously reserved for bypass surgery. *Treatment substitution* occurred, which allows a patient to shift from more- to less-intensive (and expensive) interventions. Therefore, the increase in costs was offset over time due to substitution of angioplasty for bypass surgery. Given the success of the angioplasty (average survival after treatment is estimated at ten years) and the lower unit-costs of angioplasty compared to bypass surgery, a couple of years after its introduction, angioplasty resulted in increased medical productivity.

The most illustrative example of new procedures and new physical capital combination in health care are telemedicine and domotics. In the Netherlands, the potentials of these technology innovations are identified by the health care authorities and their role in tackling personnel shortcomings is expected to be increased in the future. A research commissioned by the Netherlands Health Care Inspectorate (Inspectie voor de Gezondheidszorg) concludes that there are personnel savings potentials by utilizing e-health and domotics under the appropriate circumstances (van der Velde et al., 2008). In addition, research by Goudriaan et al. (2005), based on the experience in Sweden and Great Britain, has shown that labor-saving innovations are underutilized in the Netherlands. Below, we provide an in-depth analysis of the impact of telemedicine and domotics on productivity savings in health care.

3.3.2 Telemedicine

Telemedicine (or telemonitoring, telehomecare, telecare, telehealth) consists of remotely monitoring the health of patients with information and communication technologies. This means that a health care provider delivers care in the place of the patient's residence (mostly the home) by means of ICT (Krupinski, 2008). Since the telemedicine consultations either replace some of the in-person visits by the health care provider, telemedicine is potentially cost saving and productivity increasing. Cost-effectiveness studies in the field of telemedicine usually have several methodological flaws, such as lack of a control group, lack of statistical power due to small sample sizes, no randomization between experimental and control groups, and lack of uniformity in costs analysis (Mair et al., 2000; Whitten et al., 2002). Despite these shortcomings, several studies show substantial cost-minimizing effects of telemedicine, mostly due to reduced hospitalizations or reduced home visits made by health care providers (Roine et al., 2001; Magnusson and Hanson, 2005). These results suggest that telemedicine programs can minimize avoidable health care service use. We focus here on studies related to telemedicine in COPD and diabetes keeping however in mind the possibilities for publication biases in the found literature.

Telemedicine for COPD or other patients suffering from pulmonary diseases includes for example a consultation of a patient via a live teleconference. During the conference, the physician conducts a partial physical exam with the use of an electronic stethoscope (Agha et al., 2002). Another example of used technology is a web phone, programmed with a personalized protocol for monitoring several parameters of patient health. The patient can collect and send clinical data over the internet. Once the information is transferred, it is reviewed daily by the nurse responsible for remote monitoring of the patient's health and compliance with the prescribed treatment (Pare et al., 2006). Alternative to these telemedicine-sessions are either home visits made by nurses or visits to the clinic made by patients. Results of the studies indicate first of all no difference on health outcomes due to telemedicine programs. Moreover, patients had almost no problems in working with the technology. Cost-savings due to the telemedicine were substantial. Pare et al. (2006) report that those COPD-patients in the telemedicine group received fewer home visits by nurses (4.2 versus 7.5), although the visits were longer (57.5 versus 46.6 minutes). They also had fewer hospital admissions (5% versus 40%), although the stays were longer than the traditional group (13.5 versus 7.3 days). The telemedicine patients also made more (2.5 versus 1.4) and longer (22.2 versus 19.9 minutes) telephone calls to the call service than

the traditional patients. When all expenses were accounted for, the telemedicine group was also shown to be more cost-efficient than the traditional group ($2,424 versus $2,779 per patient for a 6-month period), mostly due to lower hospitalization costs and reduced patient's visits and travel costs.

In the US, the Veterans Health Administration (VHA) has a rather extensive care coordination/home-telehealth (CC/HT) program for diabetes management. The VHA has embarked on a patient-centered care perspective, where the patient is the locus of control and the care environment is moved to the patient's home rather than the ambulatory setting, and aims to coordinate the patient's care by rationalizing and unifying the necessary care. The predominant type of home telemedicine technology used is a messaging device. This device operates using basic telephone service and an electrical outlet. Patients used this messaging device daily to answer scripted questions about their symptoms and health status. The program consisted of nurse care coordinators who used disease management protocols to manage treatment and to educate the veterans about their disease in order to prevent more costly interventions (hospitalizations or emergency department visits). This telemedicine program has shown success on a variety of important outcome variables (Chumbler et al., 2005; Barnett et al., 2006). Comparing records of patients before and after enrolling in the CC/HT program, they had significantly fewer hospitalizations (50% reduction), lower emergency room use (11% reduction), fewer bed days of care (decreased by 3.0 on average) and overall improvement in quality of life, pain reduction and social functioning. Chumbler et al. (2005) also find that although clinical outcomes did not differ between two groups receiving different intensities of telecare (daily versus weekly), those receiving daily monitoring had fewer hospital admissions with fewer days of care, and fewer unscheduled clinic visits.

3.3.3 Home automation

Home automation (or smart homes, domotics) consists of the application of automation techniques in a home environment. These techniques include light and climate control, control of doors and window shutters, and security and surveillance systems, and should increase the comfort and security of its residents. Home automation for the elderly focuses on making it possible for the elderly and disabled to live at home and still be safe and comfortable. There are two reasons why home automation may lead to an increased productivity of the health care sector. First, implementation of home automation may delay the move to a health care institution,

because the elderly manage to stay at their homes for a longer period of time. Secondly, home automation in a health care institution can be assistive to the medical personnel, reducing the need for human intervention. An example of the second advantage is given below.

Recently, two elderly and nursing homes in the Netherlands have been built in which home automation is implemented (Nouws et al., 2006). Residents of these homes are elderly suffering from dementia. The monitoring or safety devices that are installed in the homes include lighting and motion sensors, environmental controls, video cameras, automated timers, emergency assistance systems, and alerts. Elderly living in one of the above-mentioned smart homes have significantly less falling incidents and report a higher quality of life compared to elderly who live in a traditional environment (Lauriks et al., 2008). Although it is not mentioned by the researchers, a decreased incidence of falling incidents probably leads to reduced medical consumption. The traditional and smart homes did not differ in terms of job satisfaction and perceived work load of the personnel. Most important, due to the implementation of home automation, nurses could make fewer rounds during the nights. Since the home automation gave the personnel 'extra eyes and ears', a saving of 1-1.6 nurse could be realized during the night shifts. Given the total personnel of 25 nurses working in the smart home, this is a labor saving of about 5%.

3.3.4 Changes in health care organization and processes

In this section, we give a brief overview of international experiences of technological or procedural innovations. We focus here on experiences from Sweden and Great-Britain (Wales in particular), based on the report of Goudriaan et al. (2005). Other international experiences can be found in Appendix A.

As in the Netherlands, health policies of Great-Britain and Sweden are focused on consolidating the independency of the elderly. Consequently, the elderly are able to live longer at home, sustained by outpatient care or domotics. In Sweden, only patients that need intensive care (for example, because they suffer from severe dementia) live in nursing homes. All other patients use outpatient care. Another important part of the policies of these countries is the stimulation of self-care. In Wales, diabetes patients perform medical procedures that were previously performed by medical personnel.

Generally, in health care, a lot of work is done by relatively expensive personnel. Part of these tasks can be performed by lower educated, cheaper personnel. Great-Britain experiments with shifting some medical tasks and responsibilities of physicians to other personnel, such as specialized nurses. This leads to a more efficient use of resources and a reduction of demand of scarce physicians.

In Great-Britain, only one-third of the working-day of a medical doctor is directly related to the treatment of patients. Administrative burdens and other obligations consume the remaining hours. Reduction of administrative burdens will lead to higher productivity and more contact-hours with patients.

Technology can be of vital importance by increasing productivity in health care. Home care organizations use movement sensors in combination with alarming and intercom devices. On an experimental basis, Sweden uses pulse watches as a signaling device. By using pulse watches, less home visits are needed. In Wales, the number of home visits has been reduced by one third since the use of such technological devices. A bottleneck is the proper use of technology by the elderly. In Sweden, home care organizations give courses to the elderly to use mobile phones and intercoms. Hospitals in Wales have introduced *electronic nurse handovers.* Exchange of information between nurses is done through recording devices, which leads to reduced frequency of meetings. As a result, more time is left for contact with patients.

Labor-saving technology is often cost-effective, but this is not always the case. If technology is not cost-effective, it can still contribute to shortages of medical personnel. In Sweden for example, people at a very high age can still get an artificial hip. As a consequence, they can live independently at a high age, because they need less labor-intensive care. In the Netherlands, people above a certain age are not qualified for an artificial hip, because of cost-effectiveness considerations.

3.4 Process innovations in health care

Process (or logistic) innovation in health care is as important as pharmaceutical and technological innovations. In times of constantly increasing health care costs and demand for health services, technical efficiency is taken seriously under consideration. Process innovations allow an increase of efficiency with any given inputs.

3.4.1 Integrated care and disease management

The most promising process innovations in health care in recent times are integrated care and disease management. Integrated care is a concept that positions patients in the centre of a health care system in which multidisciplinary teams cooperate in order to provide continuous, complete, and comprehensive inpatient and outpatient care. Integrated care has a positive effect at the patient level by increasing health outcomes but, also at macro level by utilizing the available health care resources more efficiently (Kodner and Spreeuwenberg, 2002).

In Sweden, primary care has shifted towards well equipped multidisciplinary centers rather than solitary GPs. District nurses have broad responsibilities that include managing their own caseloads and doing home visits. Consequently, there is a shift towards integrated care by improving the transition between inpatient and outpatient care although this is not yet working as well as it could (Rae, 2005).

There are also initiatives in the U.K. to enhance integrated care. For instance the "Integrated Medicines Management" is a major initiative in hospital trusts. This involves a dedicated clinical pharmacy service at all parts of patient care journey from admission to discharge. It also seeks to provide a more seamless approach to pharmaceutical care across primary and secondary care and to promote consistency of treatment across the two domains (Department of Health, U.K. Government, 2004). Besides the advantage of this initiative in increasing efficiencies in pharmaceutical dispense, the advantage for the patients is that there is no change in the medication treatment as they move between primary and secondary care. In Wales the concept of *seamless care* has been introduced in the current decade (Goudriaan et al., 2005). By removing the traditional boundaries between health care and social care and combining the activities into one service less patient visits have to be made. This results in a substantial saving of labor inputs.[3]

Integrated care can be regarded, in the Netherlands at least, as the precursor of disease management. Disease management is defined as the concept of reducing health care costs and/or improving quality of life for individuals with chronic disease conditions by preventing or minimizing the effects of a disease, usually a chronic condition, through integrated care.

[3] In Wales, population ageing and the consequences for labor is a major policy problem both in health care are as well in other economic sectors.

For instance, the adoption of disease management model for diabetes in the region of Maastricht resulted in optimization of diabetes care provision (Vrijhoef et al., 2001). Another study found that a computerized decision support management program for diabetic patients leads to higher quality of life and simultaneously improves efficiency in diabetic care in The Netherlands (Cleveringa et al., 2008).

3.4.2 Distribution and retail

Another form of process innovation is new developments in the distribution of innovations in health care. Illustrative examples of such innovations are the developments in the distribution and retail of pharmaceuticals. In recent years, new forms of pharmacies were developed. Internet pharmacies captured a small but still increasing segment of the market, while certain pharmaceutical products are available in supermarkets and drugstores. Probably, the most interesting development is distribution and retail of pharmaceuticals by health insurers. In this case efficiency gains may occur since the purchasers of health care (i.e. health insurers) have a "control" over the efficient dispense of pharmaceuticals.

3.4.3 Integrations and contracts

Process innovations in health care are also the recently developed vertical and horizontal integrations and contracts of health care stakeholders. The awareness over social innovations in health care is remarkably promoted lately in The Netherlands, for instance by the Health Care Innovation Platform (ZIP), and significant attempts to bring related stakeholders together are made. Under these process innovations better performance can be achieved at roughly the same costs. Integration throughout the health care system could lead to a more efficient management of health care utilization and generate benefits derived from economies of scale and scope (Bijlsma, 2008).

There are several examples of innovative agreements of Dutch stakeholders that promote productivity increasing through efficiencies. Collective agreements include the case of a team of GPs in The Hague that negotiate on behalf of 60,000 patients a collective insurance policy (with a collective discount) with AGIS. There are also selective agreements developed with the example of the Univé health insurance policy (Zekur polis). This policy is targeted to young people (the purchasing of the contract is possible only via internet) and provides a restricted network of health care providers with which Univé has a special agreement. This health insurance

policy achieved at the moment the lowest health insurance premium in the market triggering other health insurers to find similar competitive solutions. Another preferred provider agreement is provided by the CZ health insurer to people with kidney failure. The holders of this health insurance policy are treated in Erasmus MC in Rotterdam, which was preferred by CZ because it had the lowest re-hospitalization rates of patients with kidney failure.

There are less vertical integrations than vertical agreements in the Netherlands but, it seems that the market forces are pressing to that direction. An example of a vertical (partial) integration occurs between Maxima Medical Center and CZ insurance group while the most recent example is the vertical integration of DSW health insurer and Vlietland hospital in Schiedam, However, the latter integration is not yet completed because of a debate in the parliament (Tweede Kamer) about the consequences of vertical integrations on health care quality.

3.5 Conclusions

The main conclusions of this chapter are:

- Innovative pharmaceuticals have substantially positive effects on health and labor productivity as they reduce average length of stay in hospitals, worker absenteeism and costs of other medical interventions.
- Pharmaceutical innovation could become a catalyst in the sustainability of the health care system in the shadow of rapid ageing and disease prevalence.
- Technological innovations increase quality of life, longevity, and labor productivity of the medical sector as well as they reduce worker absenteeism.
- Telemedicine (e-health) can minimize avoidable health care use by reducing hospitalizations, patient visits, and home visits by medical personnel, while in some cases it also leads to better health outcomes.
- Evidence from the Netherlands, Great Britain, and Sweden suggests that home automation can increase quality of life of elderly patients as well as it can result in substantial labor savings.
- Medical process innovations such as integrated care and disease management can increase health outcomes and labor savings in health care.

4 CASE STUDIES OF SELECTED DISEASES

4.1 Introduction

In this report, we have selected three diseases in order to study in depth the impact of innovative pharmaceuticals on productivity savings in the health care sector. In the Netherlands, depression, asthma and COPD, and cardiovascular diseases (e.g. stroke, coronary heart disease, and heart failure) make up for a high share of total health care costs (Kommer et al., 2005). RIVM has projected that this share will be even higher in 2020 based on epidemiologic trends. Therefore, the following disease clusters are selected to be examined in this study: a) COPD and asthma, b) Cardiovascular diseases, including coronary heart disease, heart failure, and stroke, and c) Mental disorders, including schizophrenia and bipolar disorder.

We attempt to include in the analysis all innovative pharmaceuticals which are introduced in the market after 1995 related to the three above mentioned disease categories. An overview of the medicines included in our selection is given in Appendix B. We carried out a literature review to find suitable information about length of stay in a (mental) hospital, admissions to a (mental) hospital, or labor savings related to the selected diseases and pharmaceuticals. Unfortunately, we did not find relevant information for all pharmaceuticals. Relevant outcomes of ten medicines are given in Appendix C. Given the results of the studies, we provide an indication of labor savings per medicine.

4.2 COPD and asthma

Chronic obstructive pulmonary disease (COPD) is an incurable and progressive respiratory disease. COPD is caused by noxious particles or gases, most commonly from smoking, which trigger an abnormal inflammatory response in the lung. Symptoms of COPD are shortness of breath, persistent cough, sputum or mucus production, wheezing, chest tightness and tiredness. The natural course of COPD is characterized by occasional sudden worsening of symptoms called *acute exacerbations*, most of which are caused by infections or air pollution. In the same cluster we also have categorized asthma.

Asthma is a chronic (long-term) lung disease that inflames and narrows the airways. Asthma causes recurring periods of wheezing (a whistling sound when you breathe), chest tightness, shortness of breath, and coughing. The coughing often occurs at night or early in the morning.

As one of the most common chronic diseases, COPD is a major cause for morbidity and mortality in the Netherlands. In 2003, about 316.000 patients suffer from COPD (corresponding to an incidence rate of 2.1/1000), while about 519,800 patients suffer from asthma. The number of COPD-patients will increase with 38.3% in 2025, while the number of asthma patients will only increase with 1.9% (Boezen et al., 2007). Worldwide, COPD is the fifth leading cause of death; the WHO predicts that COPD will become the third leading cause of death by 2030.[4] In the Netherlands, about 6,000 people die because of advanced COPD each year (accounting for 4.1% of all deaths in 2004) (Boezen et al., 2007). The mortality related to asthma is very low (76 patients in 2004). The total costs of asthma and COPD are 799 million euro in 2005, accounting for 1.2% of total health care expenditure in the Netherlands. Taken together, COPD and asthma are rated as the eighth most expensive diseases in the Netherlands (Poos et al., 2008). In the Netherlands, expenditure for hospitalizations and emergency department care represent almost 40% of all medical care costs related to COPD (RIVM, 2005). Reducing hospitalizations of COPD-patients may thus result in considerable cost-savings and increased productivity in the health care sector. The largest share of medical costs of asthma-patients is formed by pharmaceutics (53%).

An integrated care pathway with flexible shared-care arrangements between primary care and hospital, facilitated by information technologies, has an enormous potential to decrease hospital admissions of patients suffering from COPD (Seemungal and Wedzicha, 2006). An illustrative example is the evolution of a regional disease management for patients with asthma and COPD in the region of Maastricht, The Netherlands. Steuten et al. (2006) found that the integrated disease model for COPD patients has decreased the overall hospital resource utilization. In particular, the model reduced hospitalization of COPD patients by 50% and the number of sick leave days due to asthma or COPD by 55%.

An extensive study from Ruchlin and Dasbach (2001) reviewed six types of therapy for COPD patients: pharmacotherapy, oxygen therapy, home care, surgery, exercise and rehabilitation, and health education. In this study,

[4] http://www.who.int/respiratory/copd/en/

pharmacotherapy appears as the most attractive therapy for COPD with respect to lower cost-effectiveness ratios including lower health care resources utilization.

Pharmacotherapy for COPD includes anticholinergics such as ipratropium and tiotropium. These medicines dilate the bronchi and bronchioles, decreasing airway resistance and thereby facilitating airflow. Tiotropium (Spiriva®) is a newly developed, once-daily inhaled anticholinergic bronchilator. Tiotropium has been introduced to the Dutch market since 2001. Results from randomized, controlled trials showed that tiotropium leads to fewer exacerbations and to an increased time to the first exacerbation (Bubrasco et al., 2003; Casaburi et al., 2002; Oostenbrink et al., 2004; Niewoehner et al., 2005). These studies also show that tiotropium leads to fewer hospitalizations and a reduced length of stay in a hospital, although the last finding is not reported by Niewoehner et al. (2005).

Innovative pharmacotherapy for asthma includes montelukast (Singular®), a hormone antagonist acting upon leukotrienes, which may be responsible for the effects of an inflammatory response. Montelukast is a maintenance therapy, and is not used for the treatment of acute asthma attacks. Dal Negro et al. (2007) finds that patients who use montelukast have lower rates of hospitalizations compared to patients who use a placebo.

Based on the selection criteria adopted in this study (see Chapter 2), we selected the most suitable studies from the studies found for COPD and asthma. We selected Bubrasco et al. (2003) and Oostenbrink et al. (2004) to study the labor savings of tiotropium because the standard arm in these studies was not placebo in contrast with the other three excluded studies. The study of Dal Negro et al. (2007) is selected for the quantitative analysis of montelukast since there is only one study found for that medicine. The studies that are selected to be used as the input data in our analysis are marked with an asterisk (*) in Appendix C.

4.3 Cardiovascular disease

Cardiovascular disease refers to a class of diseases involving the heart or blood vessels. The most important acquired heart diseases include coronary artery disease, coronary heart disease, stroke, rheumatic heart disease, diseases of the pulmonary vessels and aorta, diseases of the tissues

of the heart, and diseases of the heart valves.[5] Plaque on the arteries (atherosclerosis) - partly as a result of high cholesterol and fat diet - is a leading cause for cardiovascular diseases. Atherosclerosis causes two main problems. First, the plaques, though long compensated for by artery enlargement, eventually lead to plaque ruptures and stenosis (narrowing) of the artery and, therefore, an insufficient blood supply to the organ it feeds. Most commonly, soft plaque suddenly ruptures, causing the formation of a thrombus that will rapidly slow or stop blood flow, leading to death of the tissues fed by the artery in approximately five minutes. This catastrophic event is called an infarction. One of the most common recognized scenarios is called coronary thrombosis of a coronary artery, causing myocardial infarction (a heart attack). The second problem caused by atherosclerosis is the forming of an aneurysm (a balloon-like budge in the blood vessel). The larger the aneurysm becomes, the more likely it is that it bursts, which will lead to death.[6]

The combination of healthy diet, exercise and smoking cessation is a means to improve serum cholesterol levels and to reduce risks of cardiovascular diseases; if not, a physician may prescribe drugs, such as β-blockers, ACE inhibitors, aspirin, or cholesterol-lowering statins. Other treatments include coronary artery bypass graft surgery – a major procedure that involves grafting a portion of vein or artery to bypass blockage in the coronary artery – and percutaneous transluminal coronary angioplasty, which involves a small incision through which a balloon-tipped catheter is threaded. Upon reaching the point of blockage, the balloon is inflated to restore blood flow.

As one of the most common chronic diseases, cardiovascular disease is a major cause for morbidity and mortality in the Netherlands. In 2003, about 1.2 million people in the Netherlands suffer from coronary heart disease, stroke, heart failure and/or aneurysm of the stomach aorta (RIVM, 2003).[7] The numbers will increase by 40-50% in 2025. Worldwide, cardiovascular disease is the first leading cause of death.[8] In the Netherlands, about 28,000 people die because of coronary heart disease, stroke, heart failure and/or aneurysm of the stomach aorta per year. The total cost of all cardiovascular diseases is 5,491 million euro in 2005, accounting for 8% of the total health care expenditure in the Netherlands. Cardiovascular

5 http://www.britannica.com/EBchecked/topic/720793/cardiovascular-disease
6 http://en.wikipedia.org/wiki/Cardiovascular_disease
7 The numbers of patients suffering from coronary heart disease, stroke, heart failure and/or aneurysm of the stomach aorta are 675,000, 216,500, 178,000 and 86,000 respectively.
8 http://www.who.int/topics/cardiovascular_diseases/en/

disease is rated as the second most expensive disease in the Netherlands (after mental disorders). Expenditure on hospitalizations and medical specialist care represent 44% of the total costs of cardiovascular disease, whereas outpatient care accounts for 28%, and medicines (including assistive technologies) account for 17% of the total costs (Poos et al., 2008). Reducing hospitalizations may thus result in considerable cost-savings and increased productivity in the health care sector.

Lichtenberg (2008) examines the effects of changes in utilization of cardiovascular drugs on hospitalizations and mortality due to cardiovascular disease. Lichtenberg (2008) uses data on the utilization of over 1,100 cardiovascular drugs in 20 OECD countries during the period 1995-2003. Countries with larger increases in the share of doses of newer drugs (post-1990 or post-1995) had smaller increases in cardiovascular disease hospital discharge rate, reduced average length of stay and reduced cardiovascular mortality rate, while controlling for several background variables, such as medical innovations, potential risk factors and demographic variables. When the utilization of new drugs had not increased during 1995-2004, the per capita expenditure on drugs would have been lower, but the per capita expenditure on hospital days would have been much higher. Lichtenberg (2008) estimates the increase in expenditure on hospital stays to be 3.7 times larger than the reduction in expenditure for cardiovascular drugs. Similarly, Cutler et al., (2007) found that the utilization of antihypertensive drugs resulted in 38% reduction in the hospital discharges for stroke and a 25% reduction for Myocardial Infarctions (MIs) compared to non-drug utilization.

An important category of innovative cardiovascular medicines are the statins, lipid-lowering drugs that reduce cholesterol levels of people with or at risk of a cardiovascular disease. Statins effectively reduce the risk of primary and secondary cardiovascular events and death. The question is whether statins effectively reduce hospital admissions. Go et al. (2006) found that within a large population of adults with heart failure, inititiation of statin therapy was associated with lower risks of hospitalization (0.219 versus 0.311 per patient-year), even after adjusting for expected differences in patients taking or not taking a statin with regard to cholesterol levels, concurrent therapies, and the propensity to take a statin. Furthermore, adherence to statin therapy is important, as persistent users of statin had a reduced risk to hospitalizations (0.52 versus 0.42 per patient-year) (Penning-van Beest et al., 2007). These results suggest that the net-effect of statins on the rate of hospitalization of statin persistent users might be around 0.1 per patient-year. Other pharmaceutical categories

that are used in cardiovascular diseases are the Angiotensin II receptor antagonists (or A-II antagonists) and in less extent, the monoclonal antibodies. Lage et al. (2001) found that using Abciximab (a monoclonal antibody) in coronary angioplasty patients instead of Eptifibatide reduces hospital length of stay per patient per year by 0.83 days.

In our literature review we have found several relevant studies for cardiovascular disease concerning on relatively new statins, namely Atorvastatin (Lipitor®) and Rosuvastatin (Crestor®). We have also found studies related to monoclonal antibodies namely Abciximab (ReoPro®), and A-II antagonists namely Candesartan (Atacand®). These studies show a reduced rate of hospitalizations in patients with acute or stable coronary artery disease or heart failure (see Appendix C).

Using the criteria adopted in this study (see Chapter), we selected the study of Kandzari et al. (2003) for abciximab, and Plosker and Keam (2006) for candesartan since these are the only available studies for these medicines. The study of Kjekshuis et al. (2007) is selected as the most suitable for rosuvastatin, although it has a placebo as a comparator. However, we cannot use the study of Ridker et al. (2008) because it is a prevention study using healthy individuals. For atorvastatin, we end up in selecting the study of Cannon et al. (2004), Pedersen et al. (2005) Scirica et al. (2005), Koren et al. (2004), Pitt et al. (1999) and LaRosa et al. (2005) by excluding studies with placebo as standard arm. All studies found for Clopidogrel (Plavix®) (i.e. Bhatt et al., 2000, 2001; Englberger et al., 2004) are used in the quantitative analysis.

4.4 Mental disorders

A mental disorder or mental illness is a psychological or behavioral pattern that occurs in an individual and is thought to cause distress or disability that is not expected as part of normal development or culture. Categories of diagnoses in these schemes may include dissociative disorders, mood disorders, anxiety disorders, psychotic disorders, eating disorders, developmental disorders, personality disorders, and many other categories. In many cases there is no single accepted or consistent cause of mental disorders, although they are often explained in terms of a diathesis-stress model and biopsychosocial model. Mental disorders have been found to be common, with over a third of people in most countries reporting sufficient criteria at some point in their life.

Services for mental disorders may be based in mental hospitals, integrated institutions for mental health care or in the community. Psychotherapy and psychiatric medication as well as supportive interventions and self-help are three major treatment options. Schizophrenia and bipolar disorder (including mania) are the most severe forms of mental disorders and pharmacotherapy is essential in their treatment (Eaton et al., 2008). Therefore, we have selected these two diseases to be included in our analysis comprising the mental disorders cluster.

Bipolar disorder is a psychiatric diagnosis that describes a category of mood disorders defined by the presence of one or more episodes of abnormally elevated mood clinically referred to as mania or, if milder, hypomania. Individuals who experience manic episodes also commonly experience depressive episodes or symptoms, or mixed episodes in which features of both mania and depression are present at the same time.

Schizophrenia is a severe form of mental illness affecting about seven per 1,000 of the adult population, mostly in the age group 15-35 years affecting in total about 24 million people worldwide. Though the incidence is low (3/10,000), the prevalence is high due to chronicity. Schizophrenia is a treatable disorder, treatment being more effective in its initial stages.

In the Netherlands, mental disorders (including dementia and mental retardation) is the most expensive disease-category. In 2004, more than 20% of all health care costs (14.2 billion) were spent on mental disorders. The costs of schizophrenia and depression are respectively 518 million (0.07% of total costs) and 773 million (1.1% of total costs) (Poos et al., 2008). An international comparison of cost of illness (COI) studies showed that resource utilization costs related to mental disorders were higher in The Netherlands than in Australia, Canada, and England (Polder et al., 2005). Remarkably, the COI of mental disorders in The Netherlands was higher in almost all studied health care sectors such as hospital and physicians, pharmaceuticals, and residential care. The authors attributed the relatively high COI of mental disorders to the comprehensive services provided by Dutch mental hospitals and the inclusion of mental residential care in Dutch COI studies in contrast to the studies from the comparator countries.

From 2002 to 2006, the users of anti-depressive pharmaceuticals increased on average by 3.6% per year in the Netherlands (GIP, 2007). This rapid growth denotes the seriousness of mental diseases as a burden in society. However, innovative pharmaceuticals may decrease the necessity

for hospitalizations or long term care of mentally ill. For instance, Dellva et al. (1997), found that the administration of Olanzapine to patients with schizophrenia can reduce admissions rate by 0.413 per year. This evidence results to labor savings in inpatient care.

Three medicines related to mental disorders are selected to be included in the analysis.[9] These innovative pharmaceuticals are: Olanzapine (Zyprexa©), Paliperidone (Invega©), and Quetiapine (Seroquel©), all atypical antipsychotics.

For the medicines for which more than one relevant studies are found, we have applied again the selection criteria used to the previous disease case studies. For Olanzapine, the study of Foster and Goa (1999), Hamilton et al. (1999), Tran et al. (1997), Dossenbach et al. (2003), Lieberman et al. (2005), Csernansky et al. (2002), Spannheimer et al. (2003), Ascher-Zvanum et al. (2004) and Tohen et al. (2005) are selected for the analysis while the study of Dellya et al. (1997) is not included because it has placebo as a comparator. Concerning Paliperidone, we selected both the study of Janical et al., and the poster of Wu et al. (2008), since the latter gives information about hospital admissions that is otherwise not available. Lage et al. (2006) is selected for the quantitative analysis regarding Quitapine because it was the only relevant study found for this medicine.

4.5 Conclusions

The main conclusions of this chapter are:

- COPD and asthma currently affect a substantial part of the Dutch population. The prevalence of COPD is high and the medical costs associated with this disease are substantial.
- An integrated COPD disease model may reduce hospital resource utilization and worker absenteeism.
- For COPD patients, pharmacotherapy appeals in having lower cost-effectiveness ratios and resource utilization than other medical treatments. Innovative pharmaceuticals for COPD contribute to productivity savings in health care by reducing hospital admissions and inpatient days.

[9] New routes of administrations of drugs originally introduced before 1995 were also excluded from the analysis. For instance, Risperdal Consta was introduced in 2003 in depot version after the original introduction of Risperdal in 1993.

- Cardiovascular disease is the deadliest disease in the Netherlands, and is associated with a relatively large share in the total health care expenditures.
- Innovative cardiovascular pharmaceuticals (e.g. statins) can reduce health care resource utilization and in some cases reduce cardiovascular mortality rate.
- Mental disorders is the most expensive disease category in the Netherlands having higher cost of illness than in other countries.
- The increasing demand of resource utilization due to mental disorders may be partly offset by the usage of innovative pharmaceuticals such as anti-psychotics.

5 QUANTITATIVE ANALYSIS

5.1 Introduction

This chapter presents a pilot quantitative analysis of the labor savings of innovative pharmaceuticals. The input data for the analysis are collected from the scientific literature as described in the preceding chapters and also from datasets available to Dutch health care institutions. We have developed a straightforward methodology for estimating the labor savings as adequately as possible within this exploratory study. The results of the analysis are estimated in numbers of hospital personnel saved in 2007 as a result of the use of ten innovative pharmaceuticals. We have projected the results to 2025 in a scenario analysis that is presented at the end of this chapter.

5.2 Methodological approach

We calculate the labor savings primarily in terms of total hospital days per disease category and per innovative pharmaceutical. Total hospital days are defined as the number of admissions in the Netherlands times the average length of stay. For example, in the Netherlands the total number of hospital days for COPD in 2004 was 222,000 days (18,500 admissions times 12 days average length of stay). To study the effect of a given innovative pharmaceutical, we compare the total hospital days *after* introduction of the innovative drug with the total hospital days *before* introduction of the innovative drug (see equation 1).

Equation 1: Saved hospital days=$(H\ adm_b * ALS_b - H\ adm_a * ALS_a) * p_{user}$

Where
$H\ adm_a$ = Hospital admissions *after* introduction of the innovative drug
ALS_a = Average length of stay *after* introduction of the innovative drug
$H\ adm_b$ = Hospital admissions *before* introduction of the innovative drug
ALS_b = Average length of stay *before* introduction of the innovative drug
p_{user} = Percentage users of the innovative drug

The most recent data available about hospital admissions and average length of stay is from 2004 (data provided by the National Institute for

Public Health and the Environment, abbreviated RIVM, see further Tables 5.1 and 5.2). We use these data to calculate admissions and average length of stay in 2007, the year referred to as 'after introduction' in Equation 1. We approximate the number of hospital admissions in 2007 using a demographic trend of the number of patients (which means that we assume that the rate of growth of the number of patients is the same as the rate of growth of the number of hospital admissions between 2004 and 2007). Furthermore, we assume that the average length of stay in 2007 is the same as the average length of stay of 2004. For example, for COPD, the estimated number of hospital admissions in 2007 is 19,422, while the average length of stay equals 12 days; in 2007, the total hospital days is therefore 233,064.

We use the data of the scientific studies to calculate the admissions and average length of stay *before* introduction of the innovative drug. Thus, we do not use real historic data on admissions or length of stay, but we give a 'backward projection' given the innovative drug would not have been introduced (see equation 2a and 2b).

Equation 2a: $H\ adm_b = H\ adm_a * (H\ adm_s / H\ adm_i)$
Equation 2b: $ALS_b = ALS_a * (ALS_s / ALS_i)$

Where
$H\ adm_a$ = Hospital admissions *after* introduction of the innovative drug
ALS_a = Average length of stay *after* introduction of the innovative drug
$H\ adm_b$ = Hospital admissions *before* introduction of the innovative drug
ALS_b = Average length of stay *before* introduction of the innovative drug
$H\ adm_s$ = Hospital admissions given treatment of a *standard* drug
$H\ adm_i$ = Hospital admissions given treatment of the *innovative* drug
ALS_s = Average length of stay given treatment of a *standard* drug
ALS_i = Average length of stay given treatment of the *innovative* drug

The scientific studies we collected compare admissions and/or length of stay of patients using the innovative medicine with admissions and/or length of stay of patients using a standard treatment. For example, Bubrasco et al. (2003) compare the treatment of the innovative drug tiotropium given to COPD-patients with the standard treatments of salmeterol and placebo. He finds that treatment of tiotropium results in 0.43 hospital admissions per COPD-patient/year, whereas treatment of salmeterol results in 0.65 hospital admissions per COPD-patient/year. Furthermore, treatment of tiotropium reduces average length of hospital stay: 2.38 days per COPD-patient/year versus 3.46 days per COPD-patient/year. Given

this information, we can calculate the 'backwards projected' hospital admissions and length of stay. The backwards projected hospital admissions are 19,422 (admissions 2007) times 1.51 (0.65/0.43), which equals to 29,327 hospital admissions. The backwards projected length of stay is 12 (length of stay 2007) times 1.45 (3.46/2.38), which equals to an average length of stay of 17.4. Given these numbers, we can estimate the total number of hospital days *before* introduction of the innovative medicine. The backwards projected total number of hospital days is 29,327 (admissions) times 17.4 (length of stay), which equals 510,289 total hospital days. Now the difference between the hospital days *before* and *after* the introduction of the innovative drug tiotropium is 510,289 minus 233,064, which is 277,225 total saved hospital days.

In the example above, we have assumed that *all* COPD-patients use the innovative drug tiotropium. This is not a realistic assumption. Therefore, we multiply the number of reduced hospital days by the percentage of users of the innovative drug (given by p_{user} in Equation 1). To calculate the percentage of users, we divide the number of users of tiotropium in 2007 by the number of COPD-patients in 2007. Maybe not all users of tiotropium suffer from COPD, since off-label prescriptions of this medicine (and other innovative medicines) occur. Since we have no information available about the number of off-label prescriptions, we have to set this complication aside. Given a percentage of users of tiotropium of 54%, the total saved hospital days are 122,702.

A few important additional remarks have to be made. First, for most pharmaceuticals, we found more than one study reporting changes in admissions and/or length of stay. In the case of tiotropium, we collected five studies that report the effects in terms of the above-mentioned outcomes. If we found more than one suitable study per medicine, we calculated the unweighted average of the relevant outcomes of the suitable studies. Furthermore, if we found more than one suitable study, we excluded studies using placebos as comparators. The reason for this decision is that the use of a placebo as comparator generally leads to larger effects than the use of a standard treatment as comparator. Thus, by selecting only studies using standard treatments as comparators, we follow a conservative approach. However, this approach was not always feasible, because for some medicines, only one study was found having a placebo as comparator (that was the case for the asthma-medicine Montelukast). In addition, some studies report only one outcome (for example, report a reduction of hospital admissions, but do not report any data on average length of stay). If for a given medicine, *none* of the collected studies report a certain outcome, we

set the relevant fraction H adm_s /H adm_i or ALS_s /ALS_i in Equation 2a respectively 2b equal to one. For example, in the case of Montelukast, we have collected one study which does not report any data in terms of average length of hospital stay. Thus, we take a neutral position, and assume that use of Montelukast does not result in reduced length of stay, by setting the equation ALS_s /ALS_i equal to one.

Given the saved total number of hospital days, we can calculate the *gross* savings in terms of medical personnel. The Bureau of Statistics of the Netherlands report data on the total number of hospital days and the total number of personnel working in hospitals. Given these data, we can give an indication of the number of saved medical specialists, nurses et cetera per innovative pharmaceutical and per disease. For example, we know that 0.0038 nurses and/or caregivers measured in full-time equivalents (fte) are needed to produce one hospital day.[10] The gross total number of nurses and/or caregivers in fte's saved as a result of the use of tiotropium is 466 (0.0038 times 122,702 hospital days avoided doe to use of tiotropium). Please note that the labor savings resulting from the previous analysis only concern inpatient care in (mental) hospitals. In other words, we calculate the *gross* labor savings in the health care sector, because the additional labor needed in outpatient care due to the shift from inpatient to outpatient is not taken into account. Ideally, we would have presented *net* labor savings. However, since we do not know the rate of substitution of inpatient versus outpatient care, we cannot give a reliable indication of net labor savings.[11] However, we can be quite confident that positive net labor savings occur if the gross labor savings are considerable.

The analysis outlined above gives an indication of gross current savings, based on data of 2007. What are the potential savings of the innovative medicines in the future? Given a probable increase of the incidence of welfare-diseases such as COPD and cardiovascular diseases, the savings in the future can be larger than today. We make a scenario analysis to estimate the gross labor savings in inpatient hospital care, based on the number of hospital admissions in 2025, and different levels of medicine users.

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[10] The number of medical personnel in hospitals was only available for total hospital care, including hospital personnel engaged in outpatient services. In order to restrict the calculations to the hospital personnel that produce hospital days, we have used the cost prices of medical personnel reported in Oostenbrink et al. (2004). Since the inpatient personnel costs are roughly 75% of total personnel costs in a hospital, we assume that the same proportion of personnel would be needed for inpatient care (see further Appendix D).

[11] The substitution rate of inpatient versus outpatient care is not reported in the studies used in our analysis.

In detail, the first component of our scenario analysis is to forecast the personnel savings in 2025 based on our current estimates. In order to do that, we extrapolate the current hospital admissions (i.e. in 2007) to 2025 by using the demographic trends per disease per year estimated by RIVM.

The second component of our scenario analysis is to project the labor savings in 2025 if the share of users of each medicine increases by 0.5%, 1%, and 1.5% per year. It should be explicitly noted that this increase is not due to disease prevalence, as it is in the first component of the scenario analysis, but due to higher usage of a medicine substance by patients of a certain disease.

To conclude, we use four scenarios for the share of users; the lower case scenario includes 0% annual growth of the share of users; the upper scenario includes 1.5% annual growth of the share of users, and the middle scenarios are in between (0.5% and 1% annual growth of the share of users).

5.3 Number of patients and hospitalizations

Given the three disease categories, we gathered information on the number of patients, number of hospitalizations, and average length of stay. The data of cardiovascular disease, COPD and asthma are summarized in Table 5.1. All data involve the Netherlands. The most recent data available for hospital admissions and average length of stay in hospitals is from 2004, while for number of patients per disease is from 2003. Facing the lack of more recent data, we have collected the demographic trends per disease that RIVM has estimated. This data is also presented in Table 5.1. Based on these demographic trends a prognosis of the number of patients and hospital admissions in coming years can be made. Given these trends, we projected the number of patients and hospital admissions from 2004 to 2007. It is also interesting to note that that the demographic trends show an increase of about 40% of most diseases in 2025 compared to 2005. This increase is due to the ageing of the Dutch population. However as can be seen in Table 5.1, this relative increase does not hold for asthma which is a disease without higher prevalence among the elderly.

Table 5.1: *Prevalence and hospitalizations for cardiovascular disease, COPD and asthma in the Netherlands*

	Coronary heart disease	Heart failure	COPD	Asthma
Number of patients 2003	675,000	178,900	316,400	519,800
Number of hospital admissions 2004 [a]	90,405	24,897	18,500	6,410
Average length of stay in hospital (in days) 2004[b]	6.8	11.4	12.0	6.0
Demographic trend 2005-2025	1.419	1.469	1.383	1.019
Demographic trend per year	1.018	1.019	1.016	1.001
Estimated number of patients 2007	723,936	193,203	337,599	521,760
Estimated number of hospital admissions 2007	95,277	26,375	19,422	6,428

[a] More admissions per patient are possible.
[b] Average number of days per admission, not per patient.

Source: RIVM (Adjusted by APE)

Data on hospitalizations and length of stay are scarcer for mental disorders. Table 5.2 gives a summary of the data we found. Again, all information involves the Netherlands. We have incomplete data for schizophrenia and bipolar disorder, partly because of the lack of registration and the difficulties in diagnosing patients. Since the numbers of patients are based on surveys, only approximations can be given, and they probably include patients who are untreated. In our analysis, we include the average of the number of patients (70,000 for schizophrenia and 200,000 for bipolar disorder). For schizophrenia, the number of patients admitted to a hospital presumably gives an underestimation of the real number of admitted patients. Trimbos Institute indicates that 28% of all patients in a psychiatric residency are psychotic (a wider definition than schizophrenic); this would account for about 25,000 admissions (van 't Land et al., 2008). The number of mental hospital admissions for bipolar disorder is estimated on a survey by Kölling et al. (2001). Results of this survey indicate that 15% of the total number of patients treated in a mental hospital suffers from bipolar disorder.

Unfortunately, we did not find any information on average length of stay in a mental hospital broken-down by disease. Therefore, we infer the number of hospital admissions and length of stay from a database including costs of psychiatric or psychological treatment.[12] In 2007, about 900.000 people

[12] These data are used for the risk-adjustment model of the health insurers in the Netherlands (van Asselt et al. 2008).

(5.5% of the Dutch population) used mental health care (treatment by general practitioners is not included). We do not have any diagnostic information, so we sum up all mental disorders together. However, given the fact that the number of people suffering from depression is around 850.000, it is clear that the number of people treated by a general practitioner and/or people who are untreated is considerably large.

Table 5.2: *Prevalence and hospitalizations for mental disorders in the Netherlands*

	Schizophrenia	Bipolar disorder	Mental disorders
Number of patients	60,000-80,000	160,000-240,000	902,658
Number of hospital admissions[a]	5,400 (1997)	approx. 13,153	87,690 (2007)
Average length of stay in hospital[b] in 2007 for total mental disorders			73.3
Average length of stay in hospital in 2007 for schizophrenic patients			90.3
Average length of stay in hospital in 2007 for schizophrenic patients with bipolar disorder			75.3
Demographic trend 2000-2025 or 2005-2025	1.079		
Demographic trend per year	1.004		
Estimated number of patients 2007	70,000	200,000	902,658
Estimated number of hospital admissions 2007	5,609	13,153	87,690

[a] One admission per patient in a mental hospital.
[b] Mean days per admitted patient.

Source: RIVM, GGZ Nederland, Trimbos Institute

During 2007, about 10% of the 900.000 users of mental care were hospitalized once or several times. Knowing the total inpatient costs for mental health and given cost-price of 200 Euros for an inpatient mental health care day, we estimated the average length of stay in a mental hospital (including long-stay institutions) at roughly 73 days. At first sight, this seems quite long, but probably the people who require inpatient care because of a mental disorder usually need a long-term treatment. The database also includes information on the chronic use of pharmaceuticals in a previous year. We select four groups of pharmaceuticals that may serve as a proxy to the diseases of interest. The use of anti-psychotics may indicate schizophrenia and the use of lithium may indicate bipolar disorder. Clearly, the relation between used pharmaceuticals and diagnosis is far from perfect

and certainly not one-to-one, as the distinction between mental disorders is fuzzy and people may suffer from co-morbidities. Nevertheless, length of stay is related to the severity of the disease (where schizophrenia is most severe and anxiety disorder is least severe). The average length of stay in hospital of patients with mental disorders is about 73 days. The average length of stay of users of anti-psychotics (indicator for schizophrenic patients) is above average (90 days), while the average length of stay of lithium users (indicator for patients with bipolar disorder) is just above the average (75 days).

5.4 Results of labor savings

We have collected from Statistics Netherlands (CBS) the total number of hospital days and the total number of medical personnel in 2006 in the Netherlands. We have collected the personnel data broken-down in four profession clusters namely: nurses and caregivers, medical specialists, other medical personnel, and other personnel. The number of medical personnel was only available for total hospital care including outpatient clinics. Since the inpatient care costs are about 75% of total hospital costs, we assume that the same share is also applicable to inpatient care personnel as compared to the total hospital personnel. Using this data, we compute the number of labor years needed to produce a hospital day or a mental hospital day. These numbers are given in Appendix D.

In addition, we compute the unweighted average of the outcomes of the selected studies. Based on these outcomes, we compute the total saved hospital days per medicine, and per actual percentage of users. A combination of these two types of information gives the labor savings per medicine and per category of medical personnel (specialist, nurse, and so on) per pharmaceutical and per disease category.

Table 5.3 gives a summary of the results. Clearly, the labor savings depend heavily on the number of users. Two pharmaceuticals in our study – Abciximab and Paliperidone – have low number of users namely 0.9% and 0.1% respectively. Possible explanations for that could be that the former medicine is used only in inpatient care and the latter medicine is relatively new (introduced in the Dutch market in 2007). As a result, the savings of total personnel generated by Abciximab and Paliperidone are 9 and 38 full time equivalents respectively. On the other hand, innovative medicines with high percentage of users like Tiotropium (54%) and Atorvastatin (50%) have substantial labor savings in total hospital personnel, namely

2,591 and 1,748 respectively. Although Olanzapine appears to have low percentage of users with both schizophrenia and bipolar disorder (18% in each disease), its labor savings amount respectively to 921 and 1,289 total personnel in psychiatric hospitals. That is probably attributed to a substantially lower hospital resources utilization of Olanzapine users comparing to the other treatments.

The total hospital personnel saved by innovative medicines concerning all disease categories (i.e. asthma and COPD, cardiovascular diseases, and mental disorders) in 2007 is 7,212 while for nurses and caregivers is 2,359, for specialists 784, for other medical personnel 1,825, and for other personnel 2,244. The total personnel savings per disease category vary from about 2,198 (in cardiovascular disease) to 2,722 (in asthma and COPD).

An interesting result is also that the medical specialists saved in all disease categories amount to 784 in 2007. That could be translated as a substantial saving in expensive personnel costs in hospitals but also, as an appealing solution for tackling the increasing demand for specialist care due to population ageing.

Another interesting finding presented in Table 5.3 is that the total number of nurses and caregivers saved in hospital care in all disease categories amounts to 2,359 in 2007. This could be seen as a promising solution to the increase of outpatient care due to chronic disease prevalence, population ageing, and substitution of inpatient to outpatient care.

Overall, the total labor savings estimated in this study and presented in Table 5.3 are in relative terms 3.6% of the current hospital personnel and 7.4% of personnel in mental hospitals. It should be reminded that these savings account only for 10 innovative pharmaceuticals regarding just three disease categories.[13] Therefore, a larger sample of pharmaceuticals will result in higher labor savings.

[13] The 10 selected pharmaceuticals amount in 37% of the available innovative pharmaceuticals concerning the three selected disease categories (see Appendix B).

Table 5.3: *Labor savings (in number of full-time equivalents) per pharmaceutical and disease category*[a]

	% users	Nurses and caregivers	Medical specialists	Other medical personnel	Other personnel	Total
Montelukast (Asthma)						
	11%	43	14	33	41	131
Tiotropium (COPD)	54%	847	282	656	806	2,591
Total asthma and COPD		*890*	*296*	*689*	*847*	*2,722*
Atorvastatin (CHD)	50%	572	190	442	544	1,748
Abciximab (CHD)	0.9%	3	1	2	3	9
Clopidrogel (CHD)	9%	105	35	81	100	320
Candesartan (Heart failure)						
	7%	24	8	19	23	74
Rosuvastatin (Heart failure)						
	20%	16	5	12	15	48
Total cardiovascular diseases		*719*	*239*	*556*	*684*	*2,198*
Olanzapine (schizophrenia)						
	18%	301	100	233	287	921
Olanzapine						
(bipolar disorder)	18%	422	140	326	401	1,289
Paliperidone (schizophrenia)						
	0.1%	12	4	10	12	38
Quietiapine (schizophrenia)						
	16%	14	5	11	13	43
Total mental disorders		*750*	*249*	*580*	*713*	*2,292*
Total		*2,359*	*784*	*1,825*	*2,244*	*7,212*

a When reading this table it should be kept in mind that the labor savings per pharmaceutical are heavily dependent on the amount of users. That should not be confused with the success of a medicine.

Source: APE

5.5 Scenarios

In our scenario analysis we have projected the labor savings presented in Table 5.3 to 2025. The methodology used for the extrapolation is presented in section 5.2. The results of the four scenarios are presented in Table 5.4.

Table 5.4: *Scenarios of labor savings in 2025 (in number of full-time equivalents) per disease category based on potential increase of new medicine users*

	0% annual growth	0,5% annual growth	1% annual growth	1,5% annual growth
Asthma and COPD				
Total personnel	3,602	3,941	4,309	4,709
- Nurses and caregivers	1,178	1,289	1,409	1,540
- Medical specialists	392	429	469	512
- Other medical personnel	911	997	1090	1,192
- Other personnel	1,121	1,226	1,341	1,465
Cardiovascular diseases				
Total personnel	3,018	3,301	3,610	3,945
- Nurses and caregivers	987	1080	1181	1290
- Medical specialists	328	359	393	429
- Other medical personnel	764	835	913	998
- Other personnel	939	1027	1123	1228
Mental disorders				
Total personnel	2,462	2,694	2,945	3,220
- Nurses and caregivers	805	881	963	1,053
- Medical specialists	268	293	320	350
- Other medical personnel	623	682	745	815
- Other personnel	766	838	917	1,002
Total diseases				
Total personnel	9,082	9,936	10,864	11,874
- Nurses and caregivers	2,970	3,250	3,553	3,883
- Medical specialists	988	1,081	1,182	1,291
- Other medical personnel	2,298	2,514	2,748	3,005
- Other personnel	2,826	3,091	3,381	3,695

Source: APE

The first scenario (see second column in Table 5.3) is also the lowest scenario case and assumes that the *share* of medicine users remains the same as in 2007, whereas the hospital admissions are increased just by the demographic trends. In this case, the total hospital personnel saved in

all disease categories amounts to 9,082, while for caregivers and nurses, and medical specialists the numbers are 2,970 and 988 respectively.

The third column of Table 5.3 presents the scenario case in which the share of users of the pharmaceuticals included in our study increases by 0,5% per year (until 2025) compared to the usage of other pharmaceuticals. In this case, the total personnel savings in all disease categories amount to 9,936 labor years of which, 3,250 are caregivers and nurses and 1,081 are medical specialists.

The next scenario case we perform is a 1% annual growth of usage of the examined medicines as a share of the medicines consumed by patients of each disease. In this case, the total hospital personnel saved is 10,864 labor years of which 3,553 are caregivers and nurses and 1,182 are medical specialists.

Our upper scenario case is presented in the fifth column of Table 5.3. In this scenario case the share of medicine users in 2025 is increasing at an annual rate of 1.5%. The results of this scenario yield a saving of 11,874 total hospital personnel for all disease categories of which 3,883 are caregivers and nurses and 1,291 are medical specialists.

6 INSTITUTIONAL BARRIERS AND DIFFUSION OBSTACLES

6.1 Introduction

In previous chapters we provide evidence on the labor savings in the health care sector generated by medical innovations. Although the labor savings are substantial and crucial in tackling of personnel shortages in health care, the diffusion and utilization of such innovations are hampered by institutional barriers. Given the information asymmetries in health care widespread regulation of health care providers, health insurers, and pharmaceutical and medical devices manufacturers is into force. Some of these regulations may generate institutional barriers that impede an efficient functioning health care system. Regulations should be flexible and shaped according to the current trends and needs of a modernized and efficient health care system.

The most obvious side effects of regulations are the segmentation of health care financing. The authorization and reimbursement of medical innovations are also affected by regulations. That leads to inefficiencies because these regulations are not taking into account benefits of medical innovations such as potential labor savings within and outside health care. In addition, there are perverse incentives in the financing of health insurers which hamper the diffusion of innovations that generate labor savings and potentially substitute inpatient care by cheaper outpatient care and pharmaceuticals. The following analysis of the institutional barriers that impede the utilization of medical innovations concern merely the Dutch health care system, but similarities with health care systems in other countries are likely to be found.

6.2 Segmentation in financing of different sectors

Although there are, at a European level, attempts to harmonize national health care systems in Europe and create a single market regulation for medical interventions, there is still extensive segmentation of health care systems at a national level (Steg and Thumm, 2001). Medical innovations and especially pharmaceutical innovations are impeded due to segmentation not only in the health care sector, but also in the overall structure of

economy. A recent international study concluded that separation of budgets makes it difficult to invest in innovation if the gains are enjoyed elsewhere. The study found supportive evidence in all examined countries; i.e. The Netherlands, Belgium, England, Sweden (Groot et al., 2005).

Due to the division of the health care into different sub-sectors (e.g. hospital care, long-term care, and health insurance) with independent responsibilities, labor savings due to innovative pharmaceuticals are hardly explicit. We have shown in preceding chapters that the utilization of innovative pharmaceuticals does not provide only direct health related benefits to patients, but also enhances less work absenteeism, costs savings in long-term care and in social security. Thus from the consumption of innovative pharmaceuticals not only different sub-sectors of health care benefit but also sectors outside health care.

Against this background, it is problematic for Dutch health insurers to finance expensive medical innovations that generate labor savings, if the financial benefits occur in other sectors than health care (by means of reduced worker absenteeism) and/or subsections in health care for which health insurers are not financially responsible (e.g. long-term care). As a consequence, medical innovations are not applied, and inefficiencies and forgone labor savings are generated.

The segmentation in the financing of the health care also provides little incentives for the development of integrated care. Under segmented care each health care stakeholder does not feel responsible for what is happening in the overall health care sector. In this view, a more encompassing view should be taken to value the benefits of medical innovations and to overcome existing segmentations in health care. Under this view, an integrated system would have major advantages by enabling for instance health insurers to realize that additional costs for innovative drugs will be offset by savings in the hospital sector (Schöfski, 2004).

6.3 Authorization and reimbursement

The process of market authorization and reimbursement of medical innovations is a crucial factor in realizing their benefits such as labor savings in health care. Delays in market authorization of medical innovations lead to foregone benefits due to their delayed utilization. Market authorization should be clearly based on adequate evidence and carefully taken decisions which take time to be prepared. However, unnecessary delays in de-

cision making in the process of market authorization and reimbursement decision-making should be avoided.

In general, new pharmaceuticals that are therapeutically equivalent to existing pharmaceuticals can be easily included in the current Dutch reference price system (GVS), although the concept of therapeutic equivalence is subject to discussion. The reimbursement limit is determined by the first introduced drug in the therapeutic cluster, which is usually an off-patent drug. Consumers are confronted with co-payments when the actual price exceeds the reimbursement limit. This mechanism stimulates cost containment, but does not stimulate innovation. The therapeutic value added of the new pharmaceuticals is often not adequately taken into account. Consumers or prescribers are directed towards non-innovative drugs, which lead to deadweight losses when the concept of therapeutic equivalence is inappropriately used. Furthermore, quality of life of patients may be negatively affected as new pharmaceuticals frequently have fewer side effects than existing (off-patent) pharmaceuticals.

When there are no therapeutically equivalent substitutes for the new innovative drug, an extensive assessment procedure is applied. As of 2005 a mandatory pharmaco-economic study is part of the assessment procedure. The mandatory study is subject to guidelines of CVZ. The pharmaco-economic studies, which may affect reimbursement decisions, should include labor-saving benefits generated by innovations in health care and in other sectors. The net labor savings should be estimated in the overall health care system and should be reported and incorporated in the cost per QALY values. The guidelines of CVZ could provide a specific framework on how to estimate the net labor savings in which pharmaceutical companies should comply when they apply for product authorization.

In addition, the formulary list should not only be determined by once in lifetime cost-effectiveness estimations of new pharmaceuticals but include a continuous screening of cost-effectiveness ratios following the cost-price trends (*including* the wage trends in health care). Relative prices are changing over time. Labor shortages in health care inevitably will lead to substantial wage increases in health care, and this will affect cost-effectiveness ratios. The same screening should also be applied for old pharmaceuticals that are already listed on the formulary list for long time without any evidence over their cost-effectiveness and impede the introduction of new pharmaceuticals in the reimbursement "basket".

Recently, the Dutch ministry of Health has acknowledged that the current GVS, based on the concept of government regulation, does not lead to optimal results. Instead, competitive forces have to be strengthened in order to achieve more socially acceptable outcomes. The current reference price system will phased out gradually. In the long run, more incentives for innovation will be in force.

6.4 Perverse incentives for health insurers

In EU it is general policy to shift patients from inpatient to outpatient care because the existing segmentation is suboptimal (Schöfski, 2004). This trend exists also in the Netherlands but, the structure of incentives within the Dutch health care sector may impede its success.

Moreover, under the Dutch health insurance regulation, the Dutch health insurers bear almost all financial non-hospital risks (including all outpatient pharmaceutical). So, if the prospective budget for these costs turns out to be insufficient, the additional costs are borne by the health insurer. This is an incentive for health insurers to keep the non-hospital costs (such as pharmaceuticals) low.

On the other hand, the prospective budget that health insurers receive for hospital care is supplemented by an ex-post compensation system.[14] Consequently, health insurers are only partly financial responsible for hospital costs. For them additional hospital costs are partly a free lunch compared to pharmaceutical cost and other outpatient costs. This financing scheme discourages substitution of inpatient care by outpatient care.

As a result, health insurers have limited incentives for promoting medical innovations which generate labor savings in hospitals, but at the same time might increase the demand of outpatient care. However, it should be noted that this ex-post compensation scheme is projected to be abolished by 2011.

Another example of perverse incentives for health insurers takes place in the long-term care (in Dutch AWBZ). The financing of long-term care is on a regional basis in which a selected health insurer is exclusively responsible for the financing of that sector in the region. However, the financing of long-term care is fully reimbursed by governmental funding that is distrib-

[14] This not the case for the so-called B-segment of hospital care.

uted to health insurers. Therefore, there are no market dynamics in long-term care. Health insurers hardly have incentives to promote labor-saving innovations.

In short, the main drawbacks of the perverse incentives for substitution of inpatient to outpatient care by the health insurers in the Netherlands are:

- They impede the shift from inpatient to outpatient care.
- They lower the efficiency of the overall health care sector.
- They obstruct the realization of labor savings in inpatient care generated by the utilization of medical innovations.
- They hamper potential solutions in tackling personnel shortcomings in health care.

7 DISCUSSION AND CONCLUSSION

7.1 Discussion

Population ageing increases not only health care expenditures, but also the demand for health care personnel. The shortages of medical personnel in coming years are forecasted to be critical for a sound functioning of the health care sector in The Netherlands. Against this background, policy measures should be taken to counteract labor shortages in health care. However, the labor savings of health care innovations are rarely discussed in the literature or in public debates to the extent they should be. This study attempts to give a first insight into the labor savings in health care generated by innovative medical interventions and outline the institutional barriers that obstruct the diffusion and utilization of these innovations.

For the purposes of this study, we have conducted a systematic literature review to collect evidence on labor savings of medical innovations and to collect data for the empirical analysis. International and Dutch literature were combined with the personal expertise of the authors in order to identify the institutional barriers that impede the efficient utilization of medical innovations in The Netherlands.

Findings from the scientific literature show that pharmaceutical, technological and process innovations in health care have substantial effects on labor productivity in the health care sector. In the same line are the results of the quantitative analysis that focuses on labor savings in hospital medical personnel generated by the utilization of innovative pharmaceuticals. The results of the analysis demonstrate that a substantial number of (non)medical personnel in hospitals could be saved from the utilization of innovative pharmaceuticals. The findings of this study support the opinion that medical innovations are a plausible solution to the increasing scarcity of medical personnel in health care due to the ageing of the Dutch population. The labor savings generated by medical innovations can reduce the workload of health care personnel. If these innovations are not utilized then the workload of health care personnel will be too high and more medical "hands" will be required for adequate health care delivery.

However, the potentials of medical innovations are obstructed by institutional barriers that exist in the Dutch health care sector. In order to fully

exploit the labor-saving potentials of innovations in health care, the institutional barriers should be removed and an efficient diffusion of these innovations should take place.

In our quantitative analysis, we have examined only the impact of pharmaceutical innovations on inpatient care. Since the reduction in demand for inpatient care might be (partly) offset by increases in demand for outpatient care, the quantitative analysis estimated the *gross* labor savings of innovative pharmaceuticals. The *net* labor savings of innovative pharmaceuticals would be calculated by examining also their impact on outpatient care. However, there is no concrete evidence about substitution between inpatient and outpatient care available neither in the literature nor in the Dutch health care institutions. Therefore, the estimation of net labor savings of innovative pharmaceuticals is beyond the scope of the current study. However, we assume that the savings in inpatient care are higher than any potential increasing costs in outpatient care. This assumption relies on the fact that inpatient care is substantially more costly, for instance by having more "expensive" personnel, than outpatient care. This assumption is also in line with current policy trends towards shifting patients from inpatient care towards outpatient care.

7.2 Conclusions

7.2.1 Data availability

As an exploratory study of labor savings, this report concludes also about the data availability for conducting such research. The first data scarcity we faced in this study concern the labor savings of technological and process innovations. Concerning technological innovations such as telemedicine and domotics, the few cost-effectiveness studies we found relevant to telemedicine and domotics have several methodological flaws and lack of statistical data. This is surprising since one of the aims of developing and using telemedicine and domotics is to reduce the needs for expensive health care resources such as hospital personnel and beds. Scarcity of concrete scientific results holds also for process innovations in health care. The studies for instance over integrated care and vertical integrations in health care provide limited evidence on the impact of these innovations to the health care resource utilization. Efficiency increase is a concept that is widely used in these studies, but concrete estimations of such increases are hardly reported.

The second source of data scarcity we came across during this study, concern the input data for the quantitative analysis. In particular, there are a limited number of economic evaluations of pharmaceuticals that report on hospital admissions or days, personnel savings, and so on. In most pharmaco-economic studies where resource utilization effects are measured, the provided outcomes are only in the form of monetary units. That makes the transferability of these results to other health care settings difficult, because the cost pricing of resource utilization or the health care system per se may differ remarkably. Therefore, it is also important to present useful by-results such as the magnitude of labor savings or the number of hospital admissions or days saved. Apparently, health technology assessment is focused merely on cost-effectiveness ratios and aims to develop sophisticated methods for measuring utility outcomes. Although these analyses provide deep utility evaluations, they provide segmented evidence in decision-making. For instance, economic evaluations of medical innovations which report on health care resource utilization effects, examine either this effects in inpatient or in outpatient care. As a result, the net labor savings of medical innovations in the overall health care sector are difficult to estimate.

7.2.2 Labor savings of technology and process innovations in health care

From the literature review conducted in this study it can be concluded that innovations in medical technology and health care processes increase productivity in health care. One of the most important findings in the literature is that innovations in medical technology lead to treatment substitutions from expensive to less costly treatments. That could be seen as an offset to expensive technological innovations but also as a solution to the increasing hospital costs.

The main conclusions of this study related to the labor savings of medical technology and process innovations are:

- Technological innovations increase quality of life, longevity, and labor productivity of the medical sector as well as they reduce worker absenteeism.
- Telemedicine (e-health) can limit avoidable health care use by reducing hospitalizations, patient visits, and home visits by medical personnel, while in some cases can also lead to better health outcomes.
- Evidence from the Netherlands, Great Britain, and Sweden suggests that home automation can increase quality of life of elderly patients as well as it can result in substantial labor savings by reducing health care utilization.

- Medical process innovations such as integrated care and disease management can increase health outcomes and efficiency in health care.
- Efficiency gains can also be generated by medical process innovations such as new distribution and retail processes, and integrations and agreements among health care stakeholders.

7.2.3 Labor savings of innovative pharmaceuticals

From the findings of the literature review we conclude that innovative pharmaceuticals increase labor productivity in the health care sector. The main conclusions based on the evidence of the literature findings are:

- Innovative pharmaceuticals have substantial positive effects on health and labor productivity, while they reduce average length of stay in hospitals, worker absenteeism, and lowers costs of other medical interventions.
- Innovative medicines have a positive impact on labor supply since there is evidence that they increase the per capita labor supply. This is due to two reasons. The first is that workers are in better health conditions during their working time and the second is less worker absenteeism.
- Pharmaceutical (and other medical) innovation could become a catalyst in the sustainability of the health care system in the shadow of rapid ageing and disease prevalence.

These positive findings for the impact of innovative pharmaceuticals on labor savings in health care can be countered by the argument that innovative pharmaceuticals are the drivers of ballooning health care budgets. However, a long-term perspective should be taken when evaluating the impact of innovative pharmaceutical on health care budgets and benefits such as labor savings generated by their utilization should be incorporated in the calculations.

From the three case studies we carried out in this study it appears that the costs of cardiovascular diseases, COPD and asthma, and mental disorders are substantial as share of the overall health care costs in the Netherlands. Combining this evidence with the high prevalence of these disease-clusters we expect that any labor savings related to these diseases would have a significant impact on health care productivity. Pharmacotherapy including innovative pharmaceuticals concerning patients of COPD and asthma, cardiovascular disease, and mental disorders is presented in the literature as an attractive therapy with respect to cost-effectiveness ratios and health care resource utilization.

The evidence on labor savings of innovative pharmaceutical utilization found in the literature are supported by the results of the quantitative analysis in the current study. The quantitative analysis includes ten innovative pharmaceuticals related to the three disease-clusters: a) COPD and asthma, b) cardiovascular disease, and c) mental disorders. Our empirical results show that the hospital personnel savings generated by the utilization of the ten selected innovative medicines are substantial. The main findings of the analysis are:

- Concerning COPD and asthma there are 2,722 full-time hospital employees saved within a year by the utilization of two innovative pharmaceuticals. From those, 296 are medical specialists and 890 nurses and care givers.
- The total hospital personnel saved by the utilization of the five innovative medicines related to cardiovascular disease are 2,198, of which 239 are medical specialists and 719 are nurse and caregivers.
- Due to the utilization of the three innovative medicines dispensed to patients with mental disorders, 2,292 total mental hospital employees, of which 249 medical specialists and 750 nurses and caregivers, are saved in a year.
- Combining these results, we conclude that the utilization of 7,212 (psychiatric) hospital employees is saved annually by the utilization of ten innovative pharmaceuticals. From those, 784 are medical specialists and 2,359 are nurses and caregivers. This corresponds to 3.6% of personnel of hospitals, and 7.4% of personnel of mental hospitals.

From the scenario analysis we performed over the labor savings of the ten selected innovative pharmaceuticals in 2025, the results are remarkably high. In the lowest scenario case, 9,082 total hospital personnel are saved, of which 988 are medical specialists and 2,970 are caregivers. These savings become even higher in the highest scenario where 11,874 total hospital employees are saved, of which 1,291 are medical specialists and 3,883 are nurses and caregivers.

These numbers show that the labor savings in health care generated by innovative pharmaceuticals are substantially high. The results concern three chronic disease categories that have a high prevalence among the elderly population. Therefore, these savings should be considered thoroughly by decision makers when designing solutions to the increasing scarcities of health care personnel due to the ageing of population. Once again, we need to mention that these savings should be also considered

when examining the impact of innovative pharmaceuticals on overall health care budget.

7.2.4 Barriers to pharmaceutical innovations

The potentials of labor-saving medical innovations are substantial. This means that at the same time the institutional barriers for an efficient and effective utilization of these innovations should be removed. For instance, the utilization of innovative pharmaceuticals is strictly regulated. Therefore, the benefits of innovative medicines, such as labor savings in health care, are insufficiently realized.

The most important institutional barriers for medical innovations in the Dutch health sector are:

- Segmented financing within the health care sector and between the Health Insurance Regulation (Zvw) and the Exceptional Medical Expenses Act (AWBZ);
- Perverse incentives in the financing of health insurers;
- The authorization and reimbursement process of new medical treatments, pharmaceuticals and other medical devices which do not sufficiently take into account societal benefits, such as labor savings in the overall economy.

7.3 Policy recommendations

Having in mind the exploratory type of the findings, some policy recommendations to health decision makers can be formulated. The recommendations are:

- The labor savings of medical innovations should be explicitly addressed in the guidelines concerning the reimbursement process of medical innovations.
- Integrated financing in the health care sector with well-positioned incentives should be developed and promoted.
- The management of (mental) hospitals should be aware of the medical innovation potentials for increasing efficiency in health care delivery.
- Medical innovations should be favorably regarded by health insurers because they increase health outcomes (i.e. quality of care) but also reduce the costs of care in the long run.
- The Ministry of Health should coordinate effectively a policy towards efficient utilization of medical innovations in which all stakeholders

(e.g. CVZ, health insurers, health care organizations) would play significant role.
- Cost-effectiveness ratios of pharmaceuticals should be frequently updated in order to account for changes in relative prices (e.g. relative wage increases in health care due to labor shortages).

7.4 Limitations of the study

One of the most important limitations of this study is the limited extent of scientific studies included in our qualitative and quantitative analysis. The scarcity of scientific studies that report health care utilization findings in hospital admissions or days, or number of medical personnel saved influences also the robustness of our results.

Another limitation is that we used international studies in our analysis. Thus it is possible that transferability and extrapolation pitfalls have occurred in our sample. However, we tried to mitigate such pitfalls as much as possible within the scope of this pilot study. Our study is a first attempt to quantify the labor savings of innovative pharmaceuticals. Unfortunately, the available empirical evidence in the literature is scant. The input data used in our quantitative analysis includes both hospital admissions and hospital days. The heterogeneity of the input data and the adjustments we had to make in order to make the data comparable might have caused "noise" in our calculation. However, it should be kept in mind that the methodology used in the quantitative analysis, of this exploratory study, is in line with the methodologies used in economic evaluations in health care.

7.5 Suggestions for future research

In this exploratory study many issues arise that could be investigated in future research. First of all, future research might include a larger sample of innovative pharmaceuticals in the quantitative analysis. In this manner, future research might give a more concrete and complete indication of labor savings in inpatient health care. At this point it should be also noted that it might be also interesting in future studies to examine the labor savings not only in inpatient care but also in outpatient care. In this manner, the net labor savings of innovative pharmaceuticals could be estimated that would give a better estimation of productivity savings in the overall health care sector.

Further research might also focus on the productivity savings of medical innovations not only in health care, but also in other sectors of the economy. That might be possible by studying the effect of medical innovations on worker absenteeism.

Moreover, future research might test the formula developed in this study for validity and reliability. When a sophisticated method is developed for analyzing the labor savings of medical innovations, then researchers could provide decision makers with information not only on costs per QALY, but also information related to medical personnel scarcity and other ageing induced problems.

Finally, a development of a framework to facilitate comparability of international results would help countries to cope with the increasing scarcities of medical personnel. An international database with labor savings data could be constructed to work as a vessel of knowledge and experiences between countries. In this international framework, a coherence of economic evaluation guidelines between countries that would include resource utilization data is desired.

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APPENDIX A : INTERNATIONAL REFORMS IN HEALTH CARE TOWARD INCREASED PRODUCTIVITY

Introduction

Table A.1 gives the proportion of the elderly of the population of several European countries. Notice that the Netherlands have a relatively low proportion of elderly in 2000 compared to Sweden, Belgium of Germany. However, this will change from 2015 and beyond.

Table A.1: *Proportion 65+ of total population, 2000-2025 (in %)*

Countries	2000	2005	2010	2015	2020	2025
The Netherlands	13.6	13.9	15.3	17.8	19.8	21.9
Denmark	14.8	18.5	16.4	18.6	20.1	21.4
Finland	14.9	15.8	17.1	20.1	22.4	24.1
Norway	15.2	14.7	15.0	16.7	18.1	19.6
Great Britain	15.8	15.7	16.4	17.6	18.3	19.2
France	16.1	16.4	16.7	18.5	20.2	21.7
Germany	16.4	14.9	20.6	21.2	22.8	24.7
Belgium	16.8	17.3	17.2	18.3	19.5	21.1
Sweden	17.3	17.3	18.2	19.9	20.8	21.6

Source: Eurostat, 2008

For this paragraph, we tried to find some innovative medical interventions that are applied in the selected countries and have impact on productivity within health care. However, there is scarce literature that discusses such issues and most of the studies focus on financing and organization restructuring of health care systems. Consequently, we provide some examples of health care reforms and of restructured settings that have increased productivity in Sweden, Finland, Norway, and the U.K.

Sweden

Stockholm model

By international standards, the Swedish health care system appears to be one of the most flexible and innovative. The so-called "Stockholm model" is the most well known innovation in Sweden, and although it started from the Stockholm district has been implemented in other regions as well (Rae, 2005). The Stockholm model was introduced in 1994 and is an internal market system that includes DRGs and per-case payments (similar to the Dekker reform in The Netherlands). This reform has increased the productivity and efficiency of health care providers (Quay, 2001).

Furthermore, in Stockholm County, a separation between purchasers and providers was introduced. Nine semi-autonomous district health authorities were established with purchasing responsibility for medical care and public health. These authorities were to establish contracts with providers specifying volume and quality. That seems to have increased productivity by means of increased competition among health care providers.

Decentralization

The high degree of decentralization is one of the contributing factors of the Swedish flexibility in health care sector. Locally elected county councils are responsible for financing and procuring health care. The county councils have the right to levy taxes, although from time to time the government has exercised control over local taxes, prohibiting or setting a ceiling on their increase. Some counties have run with this freedom and have been at the leading edge of international trends in health care.

Furthermore, the elderly-care system in Sweden underwent major organizational changes following the Adel reforms in 1992 when responsibility for long-term medical care of the elderly and disabled was transferred from county councils to municipalities. The aim was to change the culture from medical to social care. Municipalities became financially responsible at the same time and now have strong financial incentives to find care outside the hospital because they have to reimburse county councils for patients who are medically ready to be discharged but who stay in hospital. In one swoop that moved around 40,000 "bed blockers" out of expensive acute care beds and into other forms of care – either at home or in a municipal nursing home (Anderson and Arlberg, 2000).

Over the last decade, pharmaceutical costs have increased substantially. This increase is due to switch to new, more expensive, pharmaceuticals. An important reform is decentralization of responsibility for financing of pharmaceuticals prescribed in ambulatory care. Since 1997, the county councils have gradually taken over the funds and the costs from the government (Carlsson et al., 2000). From an economic perspective, drugs are viewed as equal to other technologies. Cost containment and cost effectiveness of pharmaceuticals is a major issue among health care providers and managers in Sweden.

Activity-based payment

In addition to these reforms, activity-based payments were introduced in Sweden in the beginning of the 1990s. Activity-based payments are based on diagnoses related groups (DRG; Dutch equivalent: DBC), of which the prices are fixed in advance. The introduction of activity-based payments led to an increase in productivity in several countries. For example, a comparative analysis of several OECD-countries showed that activity-based payment is negatively associated with waiting times for elective surgery (Sicilian and Hurst, 2003). After the introduction of activity-based payments in Sweden, productivity in the Stockholm hospitals was estimated to increase by 20% (Mikkola et al. (2002) or 10-15% (Hakansson, 2000). Costs also fell, because the DRG prices were reduced year-by-year. The productivity increase was a consequence of decreased average length of stay, an increase in number of operations and faster turnover of patients (Street et al., 2007). One main problem arose however - the rise in output induced by the new system led to budget over-runs. However, the productivity increase was temporary, as in Stockholm County the productivity of the hospitals in 1997 approximated the level back in 1991.

Finland

Decentralization

In Finland, municipalities have, by law, the main responsibility for arranging basic services such as social and health services since the reform of the health care sector during the early 1990s. Municipalities in Finland have the right to levy taxes, but they also receive a subsidy from the state. Regulations on health care arrangements are not very detailed. Significant variations, both in clinical practice and in the delivery of health services, have been enhanced by decentralization. For example, the num-

bers of inpatient cases and surgical procedures per capita vary markedly from region to region and the differences cannot be explained by different levels of morbidity or age and gender structure. Municipalities further have considerable freedom in the amount of out-of-pocket payments that are charged (Järvelin, 2002).

Considerable improvements in productivity were achieved by the health centers (Häkkinen and Lehto, 2005) and somatic hospitals (Linna, 1999) in Finland since the reform of the early 1990s. Despite decreased expenditure, more service outputs (e.g., visits to doctors, admissions, and many specific procedures) were delivered. The reform of the Finnish health sector - i.e. decentralization - may be one of the factors that contributed to increased productivity in the early 1990s, besides biotechnological improvements and economic constraints.[15]

Enhanced primary care

Strong primary care based systems are cheaper to operate than more "open" systems. One study conducted in OECD countries found that systems with gate keeping GPs were better able to control the costs of ambulatory care (Delnoij et al., 2002). In Finland, the number of contacts with physicians is relatively low. One of the reasons for this low number of contacts is that other medical personnel like nurses and midwives play an important role. Nurses and midwives may carry out tasks that their colleagues in other countries may not do, especially in the field of maternal and child health (Järvelin, 2002).

Norway

Decentralization

In Norway, the implementation of activity-based funding has had positive effect on efficiency both in terms of reduced waiting times and improved activity (Kjerstad, 2003, Biørn et al., 2003). In a recent study, Hagen et al. (2006) analyze the effect of the introduction of activity-based payments on hospital efficiency (Hagen et al., 2006). They find that the introduction of activity-based payment affected technical efficiency positively and significantly while the effect of cost efficiency was insignificant. The

[15] By the start of the reforms in 1991, Finland fell into an exceptionally deep recession that lasted until 1993.

effect of activity-based payment on technical efficiency was between 4 to 5% (technical efficiency is measured as hospitals ability to produce more output with the same amount of input).

United Kingdom

Purchase- provider split

In 1991, the UK Government introduced into its National Health Service (NHS) a 'quasi market' for hospital services. Newly established purchasers, District Health Authorities and General Practice Fund Holders, were allocated budgets and were required to purchase care from autonomous hospitals. At least one, if not the primary intention, was to improve the efficiency of health care providers through competition. There were small improvements in some efficiency indicators in the United Kingdom, but there was no sustained improvement in waiting lists or waiting times, and no measurable improvement in the clinical quality of care or in health outcomes and, hence, in patient satisfaction (Smee, 2000). GP Fund Holders are thought to have had somewhat greater success in achieving cost savings through purchases of excess hospital supply (Le Grand, 1999).

APPENDIX B: SELECTED INNOVATIVE PHARMACEUTICALS

Table B.1: Pharmaceuticals per disease category

COPD/Asthma		
	ciclesonide	(2004)
	montelukast	(1997)
	tiotropium	(2001)
Cardiovascular diseases		
	candesartan	(1997)
	eplerenon	(2002)
	valsartan	(1996)
	zofenopril	(1999)
	clopidogrel	(1998)
	atorvastatine	(1997)
	ezetimib	(2002)
	rosuvastatine	(2002)
	barnidipine	(1999)
	eprosartan	(1997)
	irbesartan	(1997)
	lercanidipine	(1997)
	nebivolol	(1995)
	telmisartan	(1998)
	valsartan	(1996)
	zofenopril	(1999)
	olmesartan	(2003)
Mental disorders		
	aripiprazol	(2002)
	olanzapine	(1996)
	quetiapine	(1997)
	citalopram	(1995)
	duloxetine	(2004)
	escitalopram	(2004)
	paliperidone	(2007)

APPENDIX C: OUTCOMES OF INNOVATIVE PHARMACEUTICALS IN TERMS OF LABOR SAVING

Table C.1: *Collected studies*

Study	*Publication*	*Disease category*	*Study population*	*Standard arm*	*Experimental arm*
1	Dal Negro et al., 2007	COPD and Asthma	Patients with asthma and co-morbid seasonal allergic rhinitis	Placebo	Montelukast
2	Bubrasco et al., 2003	COPD and Asthma	Patients with COPD	Salmeterol	Tiotropium
3	Casaburi et al., 2002	COPD and Asthma	Patients with COPD	Placebo	Tiotropium
4	Friedman et al., 2004	COPD and Asthma	Patients with COPD	Placebo	Tiotropium
5	Niewoehner et al., 2005	COPD and Asthma	Patients with COPD	Placebo	Tiotropium
6	Oostenbrink et al., 2004	COPD and Asthma	Patients with COPD	Ipratropium	Tiotropium
7	Lage et al., 2001	CVD	Coronary angioplasty patients	Eptifibatide	Abciximab
8	Kandzari et al., 2003	CVD	Patients with acute myocardial infarction	Angioplasty, stent impl	Abciximab
9	Penning-van Beest et al., 2007	CVD	New users of statins	No adherence to statin therapy	Adherence to statin therapy
10	Cannon et al., 2004	CVD	Patients with acute coronary syndrome	Pravastatin	Atorvastatin
11	Koren et al., 2004	CVD	Patients with coronary heart disease	Usual care	Atorvastatin
12	Pedersen et al., 2005	CVD	Patients with stable coronary artery disease	Simvastatin	Atorvastatin
13	Pitt et al., 1999	CVD	Patients with stable coronary artery disease	Angioplasty	Atorvastatin
14	Schwartz et al., 2001	CVD	Patients with acute coronary syndrome	Placebo	Atorvastatin
15	LaRosa et al., 2005	CVD	Patients with stable coronary heart disease	Atorvastatin (10 mg)	Atorvastatin
16	Scirica et al., 2006	CVD	Patients with acute coronary syndrome	Pravastatin	Atorvastatin

17	Plosker & Keam, 2006	CVD	Patients with heart failure	Placebo	Candesartan
18	Kjekshus et al., 2007	CVD	Older patients with systolic heart failure	Placebo	Rosuvastatin
19	Ridker et al., 2008 (prevention study)	CVD	Healthy individuals with elevated high-sensitivity B-reactive-protein	Placebo	Rosuvastatin
20	Go et al., 2006	CVD	Patients with heart failure	No statin therapy	Statin therapy
21	Bhatt et al., 2000	CVD	Patients with astherosclerosis (stroke, MI, per art dis)	Aspirin	Clopidogrel
22	Bhatt et al., 2001	CVD	Patients with a history of bypass surgery	Aspirin	Clopidogrel
23	Englberger et al., 2004	CVD	Patients with a history of bypass surgery	Aspirin, heparin or no medicine	Clopidogrel
24	Dossenbach et al., 2003	Mental disorders	Patients with schizophrenia	Risper., quetiapine, haloperidol	Olanzapine
25	Lieberman et al., 2005	Mental disorders	Patients with schizophrenia	Risperidone, perphenazine, ziprasidone, quetiapine	Olanzapine
26	Csernansky et al., 2002	Mental disorders	Patients with schizophrenia	Risperidone	Olanzapine
27	Spannheimer et al., 2003	Mental disorders	Patients with schizophrenia	Haloperidol	Olanzapine
28	Dellva et al., 1997	Mental disorders	Patients with schizophrenia	Placebo	Olanzapine
29	Foster & Goa, 1999	Mental disorders	Patients with schizophrenia	Haloperidol	Olanzapine
30	Hamilton et al., 1998 (abstract)	Mental disorders	Patients with schizophrenia	Haloperidol	Olanzapine
31	Hamilton et al., 1999	Mental disorders	Patients with schizophrenia	Haloperidol	Olanzapine
32	Tran et al., 1997	Mental disorders	Patients with schizophrenia	Risperidone	Olanzapine
33	Ascher-Zvanum et al., 2004	Mental disorders	Patients with schizophrenia	Risperidone	Olanzapine
34	Tohen et al., 2005	Mental disorders	Patients with bipolar disorder	Lithium	Olanzapine
35	Janicak et al., (2008)	Mental disorders	Patients with schizophrenia	Pre-post therapy	Paliperidone
36	Wu et al., 2008 (poster)	Mental disorders	Patients with schizophrenia	Pre-post therapy	Paliperidone
37	Lage et al., 2006	Mental disorders	Patients with schizophrenia, bipolar disorder or depression	Pre-post therapy, pre-olanzapine or risperidone	Quetiapine

Table C.2: *Outcomes collected studies*

Selection	Study	St. arm	Exp. arm	Outcome	Outcome unit
	1	15.70	14.30	1.098	No outpatient visits per patient per year
*	1	12.00	3.33	3.604	No hospitalizations per patient per year
*	2	0.65	0.43	1.512	No admissions per patient per year
*	2	3.46	2.38	1.454	No days in hospital per patient per year
	2	0.86	0.43	2.000	No admissions per patient per year
	2	4.97	2.38	2.088	No days in hospital per patient per year
	3	0.16	0.09	1.872	No admissions per patient per year
	3	1.20	0.60	2.000	No days in hospital per patient per year
	4	0.16	0.09	1.778	No hospitalizations per patient per year
	4	1.17	0.59	1.983	No hospital days per patient per year
	5	0.25	0.18	1.389	No admissions per patient per 6 months
	5	1.70	1.40	1.214	No days in hospital per patient per 6 months
*	6	0.24	0.13	1.846	No admissions per patient per year
*	6	2.96	1.62	1.827	No inpatient days in general ward
	7		-0.83		No hospital days
	7		-0.48		No postprocedural hospital days
*	8	3.50	3.10	1.129	No hospital days (median, not standardized)
	9	0.01	0.00	1.238	No admissions (per patient per year)
*	10	5.10	3.80	1.342	Rate admissions due to unstable angina (two years)
*	11	0.12	0.10	1.154	Rate admissions due to unstable angina (not standardized, time period not clear)
*	11	0.05	0.04	1.314	Rate admissions due to CHF (not standardized, time period not clear)

*	12	0.05	0.04	1.205	Rate admissions due to unstable angina (not standardized, time period not clear)
*	12	0.03	0.02	1.273	Rate admissions due to CHF (not standardized, time period not clear)
*	13	0.14	0.07	2.104	Rate admissions due to worsening angina (not standardized, time period not clear, prob 18 months)
	14	0.08	0.06	1.355	Rate admissions (not standardized, time period not clear, prob 16 weeks)
*	15	0.03	0.02	1.375	Rate admissions due to heart failure (not standardized)
*	16	0.03	0.02	1.938	Rate admissions due to heart failure (not standardized)
*	17	1.06	0.85	1.243	No admissions per patient per year
*	17	16.78	15.76	1.065	No hospital days per patient per year
*	18	0.38	0.36	1.067	No hospitalizations per patient per year
	19	0.00	0.00	1.556	Rate admissions due to unstable angina per year
	20	0.31	0.22	1.420	Rate hospitalizations per year
*	21	0.15	0.14	1.102	Rate rehospitalizations per year
*	22	0.48	0.36	1.327	Rate hospitalizations per year
	23	1.90	1.10	1.727	No days in ICU
*	23	9.60	7.90	1.215	No days in hospital
*	24	0.13	0.09	1.508	Rate admissions
*	25	0.17	0.11	1.545	Rate admissions
*	26	0.48	0.44	1.091	Rate admissions
*	27	48.20	48.10	1.002	No days in hospital
	28	0.70	0.29	2.444	Rate admissions per year
*	29	67.40	53.70	1.255	No hospital days per patient per year
	30		-14.00		No hospital days per year
*	31	8.92	7.76	1.149	No hospitalization days in acute phase (per 6 weeks of treatment)
*	31	15.94	10.17	1.567	No hospitalization days in maintenance phase (per 46 weeks of treatment)

*	32	4.50	3.90	1.154	No hospitalization days per month
*	33	0.24	0.14	1.674	Rate hospitalizations per year
*	33	14.50	9.90	1.465	No hospital days per year
*	34	0.23	0.14	1.601	Rate hospitalization (not standardized, time period not clear)
*	35	13.20	3.10	4.258	No hospital days per patient per year
*	36	17.30	5.10	3.392	No hospital days per patient per year
*	36	1.10	0.50	2.200	No hospital admissions per patient per year
	36	0.40	0.10	4.000	No emergency room visits per patient per year
	36	3.20	0.90	3.556	No day or night clinic visits per patient per year
	36	0.50	0.20	2.500	No psychotherapy sessions per patient per year
*	37			1.046	Rate hospitalizations during 6 months
	37			1.030	No visits ED during 6 months
	37			1.001	No hospitalizations during 6 months

APPENDIX D: TOTAL HOSPITAL DAYS AND TOTAL MEDICAL PERSONNEL IN THE NETHERLANDS

Numbers of medical personnel is only available for total hospital care, inclusive outpatient care. Since the inpatient care is about 75% of total hospital costs, we have assumed that the same proportion of personnel is needed for inpatient care.

Table D.1: *Personnel per hospital and mental hospital day*

	Hospitals incl. outpatient care	Hospitals excl. outpatient care	Personnel per hospital day	Mental hospitals	Personnel per mental hospital day
Nurses and caregivers	58,960	44,220	0.0038	12,422	0.0015
Medical specialists	19,610	14,708	0.0013	4,401	0.0005
Other medical personnel	45,620	34,215	0.0030	6,289	0.0008
Other personnel	56,100	42,075	0.0037	7,749	0.0009
Total personnel	180,290	135,218	0.0118	30,861	0.0037
Total hospital days		11,487,000		8,348,000	

Source: CBS (adjustments by APE)