The Hague Centre for Strategic Studies

TNO

STRATEGY & CHANGE

TAKING CARE OF OUR HEALTH

RESEARCH TACKLING EUROPE'S GRAND CHALLENGE OF FUTURE HEALTH ISSUES

THE HAGUE CENTRE FOR STRATEGIC STUDIES AND TNO

TNO

STRATEGY & CHANGE

TAKING CARE OF OUR HEALTH
THE HAGUE CENTRE FOR STRATEGIC STUDIES AND TNO

REPORT Nº 2012•14
ISBN/EAN: 978-94-91040-72-6

Authors: Eline Chivot, Maarten Gehem and Stephanie Lingemann

The authors would like to thank the following people for their valuable contributions:
Paulien Bongers, Director of Innovation Work & Employment at TNO
Peter van Dijken, Director of Innovation Biomedical Innovations at TNO
Govert Gijsbers, Senior Advisor Strategy and Policy at TNO
Jan van der Greef, Principal Scientist, Earth, Environmental and Life Sciences at TNO
Ben van Ommen, Principal Scientist and Program Director Systems Biology at TNO
Cees Wevers, Senior Research Scientist Work & Health at TNO

Graphic Design: Studio Maartje de Sonnaville, The Hague

HCSS, LANGE VOORHOUT 16, 2514 EE DEN HAAG
T: +31 (0)70-3184840 E: INFO@HCSS.NL
W: STRATEGYANDCHANGE.NL

TAKING CARE OF OUR HEALTH

RESEARCH TACKLING EUROPE'S GRAND CHALLENGE OF FUTURE HEALTH ISSUES

THE HAGUE CENTRE FOR STRATEGIC STUDIES AND TNO

TNO

STRATEGY & CHANGE

TNO and The Hague Centre for Strategic Studies (HCSS) program Strategy & Change analyzes global trends in a dynamic world affecting the foundations of our security, welfare, and well-being.

The program attempts to answer the critical question: what are the policies and strategies that must be developed to effectively anticipate these emerging challenges?

Strategy & Change provides both a better understanding and feeds the agenda for a sustainable future society.

TABLE OF CONTENTS

"IF YOU THINK RESEARCH IS EXPENSIVE, TRY DISEASE"

MARY W. LASKER (1901 – 1994)

THE GRAND CHALLENGES PROJECT

Over the past century, Europe has become more and more prosperous. We are healthier, richer, safer and live longer than ever before. But there is a downside to this success: it poses new challenges that threaten our future wellbeing. Ironically, many of these challenges are the price we pay for progress. Our economic growth comes at the cost of a changing climate and resource scarcity; new technologies breed new types of international organized crime; modern lifestyles lead to new diseases; increasing life expectancy puts pressure on public finances; and new production patterns lead to food safety concerns. Policy makers, researchers, companies and citizens in Europe need to look at ways to deal with these trends. The Grand Challenges project aims to further the debate by looking at how we can use research and development to tackle the most pressing societal challenges to Europe's future. In six separate reports, we highlight Grand Challenges on six key issues. We show how these developments may impact our future and how science can address these challenges and create new opportunities for European societies.

MANAGEMENT SUMMARY

European countries top most of the health charts. Yet our increasing wealth has given rise to a series of health challenges that are typical to high-income countries. The paradox that prosperity in itself can lead to new health issues is at the heart of this report. It presents an overview of the positive and negative health trends in Europe, and shows how science, technology, and innovation can help to address these developments.

HEALTH CHALLENGES OF PROSPERITY

That the health of Europeans ranks as one of the best in the world is illustrated by our 'Health of Nations Monitor', which maps the overall health situation for countries worldwide. But wealth can also lead to new health challenges in four distinct ways.

- First, growing national income is associated with an **increase in certain risk drivers** of health and health-care related issues. The rise of such health issues may result from rapidly *aging* societies, due to which the prevalence of age-related diseases and social and economic consequences multiply; and *unhealthy lifestyles*, such as smoking, calorie-rich diets, and insufficient physical activity leading to related diseases.
- A second reason why health issues are typically different in high-income countries is that **with wealth, health preferences shift**. More post-material concerns and the greater importance attributed to quality of life typically emerge from societies that have reached a certain level of prosperity. For the financial sustainability of health-care systems this is a particular concern. In addition, there is a rising awareness among prosperous societies about *climate change and pollution*, which speed up the spread and incidence of diseases such as asthma and ozone-induced cancers.
- Third, **knowledge of health issues has increased**. Such knowledge generally leads to a greater awareness among governments and citizens, especially in high-income countries, where most research is conducted and where people have greater access to good education.

- Finally, **wealthy societies have more to lose**. Due to high levels of productivity, tighter labor markets and high education levels, the financial burden of illness is more considerable in rich countries than in poorer parts of the world.

Aging, unhealthy lifestyles and, to a lesser extent, environmental issues, are expected to **increase the burden of non-communicable diseases** (NCDs) in terms of deaths, squandered wealth and, in some cases, healthy life years lost (or DALYs: Disability-Adjusted Life Years). Total deaths due to related NCDs are predicted to increase up until 2030. Recent calculations predict that cardiovascular diseases (CVDs), mental health issues, and cancers, would all place a substantial drag on our economies, leading to losses in economic output of $9 trillion, $8.5 trillion, and $5.4 trillion respectively. And when considering DALYs, though total healthy life years are predicted to go up, some NCDs are foreseen to rise in absolute numbers (such as diabetes and certain cancers), while the *relative* burden of total CVDs, mental disorders, and cancers are all predicted to go up.

Another 'monitor' visualizes relative vulnerability of European countries to these '**maladies of prosperity**'. The resulting map was based on data on the two most important drivers: unhealthy lifestyles and aging. Overall, eight of the ten European nations appearing 'most vulnerable' are located in Western/Southern Europe, and are regarded as the 'old' European Union members. Germany seems particularly exposed, as are a number of (poorer) Southern European countries – Greece, Italy, Portugal and Spain – and Central European countries such as Bulgaria, and Estonia.

Not only do these major risk factors threaten the health of EU citizens, they also pose **challenges for our economies at large and our health-care systems** specifically. Across Europe, public health-care expenditures are predicted to increase. Perhaps paradoxically, innovation causes most increases in public health expenditures. Advances in medical science and innovative technologies may lead to (rising demand for) new and expensive health treatments. Next to cost-increasing innovations, a 'grayer' society, with increased age-related diseases, also requires more (often long-term) care treatments. The resulting picture shows that the Netherlands, Germany, and several Central and Eastern European countries in particular are expected to face relatively steep increases in public health-care expenditures. Dealing with this phenomenon will be particularly difficult for

governments, whose budgets will be adversely affected by aging, due to both a decline in worker participation and lower tax revenues. Finally, work shortages in some sectors and decreased productivity of the workforce could lead to added economic drag.

Finally, social gaps *vis-à-vis* health inequality are likely to widen. As European economies continue to struggle, **health inequalities** are expected to remain a source of concern. The concentration of lower life expectancies in the lower social strata shows the importance of targeting health problems among people in these groups.

HEALTH RESEARCH

Based on these likely impacts, we look at ongoing health research in three areas: research on drivers (aging, unhealthy lifestyles, environmental changes); diseases (cancers, CVDs, etc.); and social and economic health issues (e.g. health inequalities, sustainability issues). In turn, we look at research priorities for private and public actors, and countries of excellence in academic research.

Governments spend a varying share of their GDP on health research, ranging from 0,35% in the US to much lower figures for Eastern European countries. Northern and Western European countries still score comparatively close to US figures, with around 0,25% of GDP spent on health research in Austria and Sweden; and 0,15% in Finland, the Netherlands, Spain, France, Germany, Denmark, and the UK. All of these countries have health research strategies in place, whereas many countries in, Eastern Europe do not. An in-depth country analysis of the health research funding of Germany, the UK, France, the US, and Japan, shows that over a quarter of funds are allocated to cancer research, followed by research on mental health issues and CVDs. In comparison, diabetes and chronic respiratory diseases receive much less funding.

EU research programs focus heavily on health, with more than €6 billion allocated under the Seventh Framework Programme and €9 billion reserved for research on "health, demographic change and wellbeing" under the next Framework Programme Horizon 2020. The programs focus predominantly on cancer research, brain research, and CVDs. Social and economic issues receive far less consideration within the FP7 budget,

where only 4.5% of the total research expenditure is devoted to these issues. Other EU-funded projects focus more on research in prevention and social inclusion.

Over half of all health research is funded and conducted by the **private sector**. Most investments are made by pharmaceutical companies, whose priority areas are: cancer, respiratory disorders, mental issues and CVDs. Though the share of research spending by European companies in % of GDP is often higher than their American counterparts, the US is the unrivalled leader in terms of patents filed. Medical device companies are also seeing their economic importance rise, which is reflected in increasing patent filings.

We use available bibliometric data to determine where **countries of excellence** are located. Looking at *drivers*, aging research is mostly produced in the US, the UK, and Canada, though articles from the UK, Denmark and Norway rank as having the most impact. As for unhealthy lifestyles, data on smoking, obesity and alcohol research show that apart from the US, the UK (smoking and obesity research), Germany (smoking research), and Finland and Sweden (alcohol research) rank as countries with most publications. In respect to research concerning environmental issues within the European Union, Germany, Sweden, and Italy represent the most productive countries. As a general observation, countries with the highest national incomes seem to publish more in this field.

For research on *diseases,* we looked at data related to cancer and mental health research. As for the first, the US, the UK and Germany produced most articles, with publications from the US, Finland and Switzerland having the highest impact. A strong growth in research production has been observed in recent years in respect to mental health issues, with the US, the UK and Germany representing the countries with the most productive research institutes. Apart from the US and the UK, publications from the Netherlands rank as one of the most impactful.

Interest in *social and economic health issues* are much more limited in terms of publications. For health economics, countries that should demonstrate growing concern for sustainability issues do not necessarily invest most in this research category. The US, the UK, and France account for most

publications, with institutes in the Netherlands, Israel, and Sweden producing most impactful research. As for health inequalities, the US, the UK and the Netherlands appear most productive.

FUTURE HEALTH RESEARCH

Finally, we suggest some building blocks for future research strategies aimed at tackling grand health challenges for Europe. In general, governments and societies would benefit from **gearing research towards diseases that are likely to become most costly**: mental health issues, CVDs, and cancers respectively. In this respect, it is interesting to note that current research efforts are focused mostly on cancers. Additionally, social and economic health issues receive relatively little funding. Research focusing on **sustainability issues and health inequalities** would benefit from more concerted attention.

In addition, we note the need for a **new health research paradigm** to limit an excessive focus on medical treatments of diseases and to acquire a more 'dynamic' conception of health. Such a definition should focus more on resilience, stress adaptation, and self-management. Furthermore, it should be both multidisciplinary and comprehensive in nature, placing a greater emphasis on social and economic issues.

Pharmaceutical research would benefit from a more **personalized approach**. A more individualized and 'customized' method, characterized by greater interaction between patients, practitioners and researchers, is expected to bring greater effectiveness to the development and administration of medicines.

Furthermore, **targeted prevention and cost-reducing innovations** may help in improving the sustainability of health-care systems. Technological research that improves the independence of the elderly could be especially promising in this respect. In addition, cost-reducing innovation deserves more attention. Wider economic benefits, particularly those related to productivity gains, should be included in future cost-benefit analyses of prevention efforts.

Lastly, regarding research in **health inequalities,** we call for a greater focus on, and increased knowledge of, the social determinants of health, and for an improvement of health literacy.

INTRODUCTION

The dramatic improvement of public health in the last centuries is undoubtedly one of the major accomplishments of the Western world. Not long ago our cities were still teeming with vermin, sewerage was an incredible luxury, and few people knew about basic hygiene. Today, we no longer have to worry about infectious diseases, and access to health care is more or less guaranteed in most European countries. This progress is to a large extent due to our increase in wealth, which allowed us to invest in medical science and improve the living conditions among large segments of the population. But while our increasing wealth has in many ways been part of the solution, it is also a driving force of new health problems. Aging, unhealthy lifestyle choices and changing health expectations all go hand in hand with rising prosperity. They increase certain diseases and threaten the sustainability of our health-care systems. These so-called 'health challenges of prosperity' constitute a primary concern of many countries in Europe.

The paradox of increasing wealth leading to new health issues lies at the heart of this report. The report consists of three major parts. The first chapter describes and visualizes the trends that are expected to challenge the future health of European societies. These trends are illustrated by several maps that offer a cross-country comparison of vulnerability for new health threats. The second chapter gives an overview of how research initiatives in health contribute to tackling these trends. Looking at the current research landscape, the third and final part of the report suggests several solutions for how research may help overcome future health and health-care challenges.

1 FUTURE HEALTH ISSUES FOR EUROPE

1.1 INTRODUCTION

This chapter focuses on the positive health conditions in the West compared to the rest of the world (section 1.2, 'Fruits' of prosperity), and the health challenges that are expected to be of growing concern for Europe (section 1.3, 'Health challenges' of prosperity). The analysis is accompanied by several maps or 'GeoRisQ Monitors', which visualize the average health situation of citizens and the impact of new health challenges for a broad number of countries.

1.2 THE FRUITS OF PROSPERITY

Europe experienced a continuous improvement of its overall health situation throughout the last decades. Life expectancy at birth has increased by six years since 1970,[1] infant mortality rates declined and several terminal diseases, such as polio, have been eradicated altogether.[2] In addition, universal access to health-care services has become a governing principle for most European countries.[3]

There are different ways to analyze cross-country differences in overall health situation. One of the most commonly used indicators is the DALYs metric (Disability-Adjusted Life Years), which measures a country's overall disease burden. Each DALY indicates a year's loss of healthy life, either through disability or premature death.[4] Not only is the total amount of DALYs in Europe very low in comparison with other parts of the world, it has also declined over the past century.[5] The World Health Organization (WHO) expects this trend to continue and foresees a further decrease of 19% within the next 20 years.

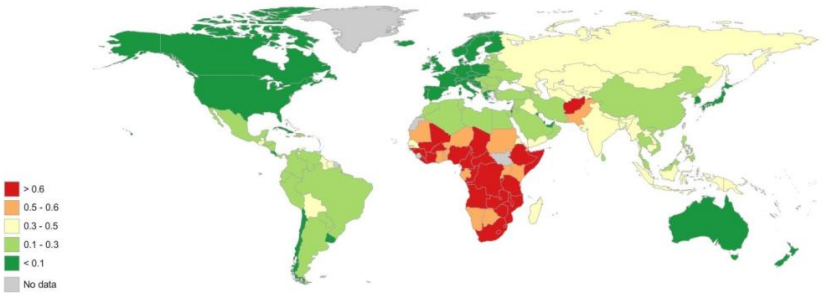
DALYs provide a rough estimate of the overall health situations of nations around the globe. At the same time, it does not tell a whole story about the various aspects of population health in different countries. Country health

rankings of organizations, such as the WHO, the World Bank or the United Nations, also include a range of other indicators, such as access to primary health care including sanitation or access to safe drinking water, but also average life expectancy at birth, the prevalence of preventable diseases or premature deaths.

MONITOR 1: THE HEALTH OF NATIONS

We used our software tool, the 'GeoRisQ Monitor', to create a data-based visualization of the relative health situation in countries worldwide. For this 'Health of Nations' monitor, we selected three measures based on a review of existing rankings from international organizations and institutes.[6] The first is *health-adjusted life expectancy*, which subtracts DALYs from the average life expectancy in a country. As a second indicator we included the *infant mortality rate*. Data is provided by the WHO, and is defined as the number of deaths of children below the age of one. This measure serves as a good indicator for both maternal and newborn health and care.[7] Third, we used data on the *adult mortality rate*, which indicates the per mille of people dying between the ages of 15 and 60 years. Since people are generally most productive in these years, this is considered an important economic measurement.[8]

An aggregate of these three measures is shown in Map 1. The lower the aggregate score a country receives, the better the health situation and the greener the color. Conversely, red indicates a negative (high) score.



MAP 1. GEORISQ MONITOR FOR 'THE HEALTH OF NATIONS': AGGREGATE SCORE INCLUDING INFANT MORTALITY, ADULT MORTALITY AND HEALTH-ADJUSTED LIFE EXPECTANCY

Unsurprisingly, the resulting image shows that the state of health is particularly alarming across Sub-Saharan Africa and South Asia, where multiple countries perform poorly on all three indicators. A completely different picture can be seen for the Western world. In North America, Australia, New Zealand, and the EU, infant mortality is below 1% for most countries, with adult mortality between 6% and 14%. Furthermore, these countries have an average health-adjusted life expectancy of over 69 years. Regarding life expectancy, European countries score especially high. This has much to do with continuous advances in medicine and health-care delivery, and the maintenance of high standards in health and health-care service. The status of health among EU member states is generally at a high level, with Sweden being the best performer. Central and Eastern Europe however score significantly lower, Hungary, Bulgaria, Romania and Latvia in particular. These countries have significantly lower health-adjusted life expectancies.

1.3 THE HEALTH CHALLENGES OF PROSPERITY

Although the overall health situation in Europe looks good, new and pressing health and health-care challenges are looming. The 'health of nations' monitor serves as a good general overview of the global health situation. At the same time, it does not provide information on the specific health problems of developed countries. This section looks at such 'maladies' and other 'health challenges of prosperity'. Below, we first give an overview of their main drivers. Then, we zoom in on possible impacts on our health and on social and economic effects.

DRIVERS OF HEALTH CHALLENGES OF PROSPERITY

Prosperity has led to new types of health issues in several ways.

First, increasing prosperity is associated with *an increase in certain risk drivers of health and health-care issues*. The rise of such health issues results from the following factors.

- Medical advances have led to a rise in life expectancy, which translates into ever-older populations. As a result, **aging** has become a demographic challenge, leading to an increased prevalence of age-related diseases and to social and economic consequences.

- **Unhealthy lifestyles**, which include smoking, alcohol consumption, calorie-rich diets, and insufficient physical activity, increase the prevalence of certain chronic diseases.

- **Climate change and pollution** speed up the spread and incidence of diseases such as asthma and ozone-induced cancers.

Second, *with wealth, health preferences shift*. More post-material concerns and the greater importance attributed to quality of life typically emerge from societies that have reached a certain level of prosperity. This explains why certain risks are perceived as much more threatening by governments and citizens that are not necessarily the most vulnerable to these hazards. For example, whereas the total effects of pollution may be less significant in developed countries, such countries may attach more value to living in less polluted environments. Furthermore, evidence shows that as most developed countries have high quality health systems in place, populations tend to gradually get used to having access to the best possible health-care services and treatments, and have higher health expectations.[9] Innovation and the increasing availability of and demand for **new and expensive health care technologies** put pressure on health-care systems. Governments and citizens in poorer parts of the world often deal with other overriding concerns. Environmental health issues may be seen as irrelevant compared to securing basic needs to survive, or as a hindrance to other more important policy priorities such as economic growth.[10]

Furthermore, *knowledge of health issues has increased*. Because of ever-expanding research activity, we now have a much clearer understanding of the health effects of smoking and pollution than we did a century ago. Such knowledge generally leads to a greater awareness of governments and citizens, especially in high-income countries where most research is conducted and people have access to good education.

Finally, *wealthy societies have more to lose*. Due to high levels of productivity, tighter labor markets and high education levels, the possible economic losses due to illnesses are simply larger in rich countries than in poorer parts of the world.

In the rest of this chapter, we examine the principal implications of the aforementioned factors for Europe. These challenges fall in two categories. First are their impacts on the health of European populations. A second group concerns social and economic challenges such as the sustainability of health-care systems and pertinent health-care inequalities among different social classes.

HEALTH CHALLENGES OF PROSPERITY: 'MALADIES' AND OTHER HEALTH ISSUES

When looking at the major current and future diseases in Europe, the three drivers aging, unhealthy lifestyles, and environmental factors are of most relevance. Before we look at the health impacts of these drivers in more detail, we first give a general projection of diseases that bear on the future health of European citizens.

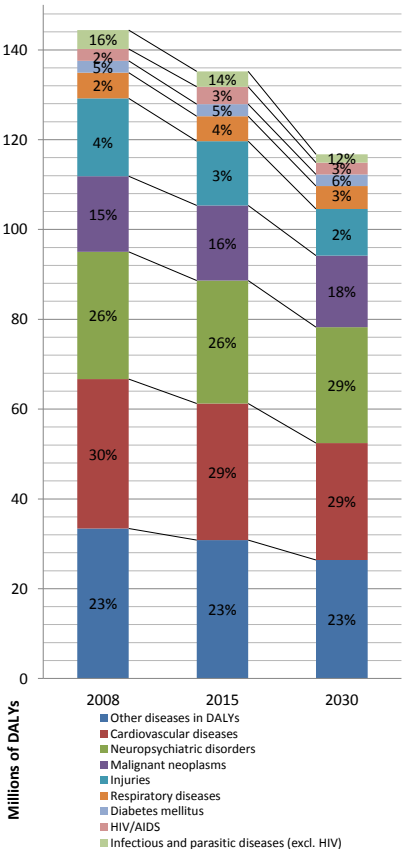


Figure 1 shows that the number of DALYs lost in the WHO European Region[11] will continue to decline in the coming decades. And overall their absolute numbers are indeed expected to slightly decrease for each of the three major diseases: cardiovascular diseases (CVDs), neuropsychiatric disorders, and malignant neoplasms (cancers). These are all non-communicable diseases (NCDs).

FIGURE 1. GLOBAL BURDEN OF DISEASE (GBD) IN EUROPE IN DALYS (WHO, 2008)

Yet this positive picture should be nuanced in three ways. First, the graph shows aggregate figures for groups of diseases. Within these, certain illnesses are actually projected to increase. Second, in terms of mortality, most cancers are expected to cause an increasing number of deaths through 2030 – in particular lung, colorectal, breast and prostate cancers.[12] This is also the case for Alzheimer's and Parkinson's, as well as diabetes.[13] Third, Figure 1 also shows that the burden of several diseases is predicted to increase in *relative* terms, especially diabetes, cancers and neuropsychiatric disorders. Therefore these will remain the greatest health challenges to European populations.

Box 1: Communicable diseases in Europe

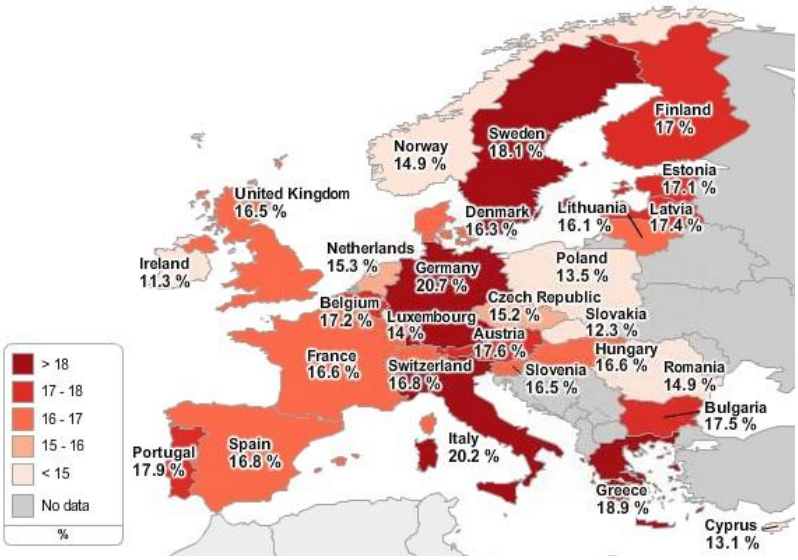
Figure 1 shows that some *communicable* diseases (CDs) are expected to remain an issue in Europe. The burden of many of these is likely to decrease, yet environmental issues and socio-demographic factors continue to contribute to the risk of exposure to infectious diseases, to which both the very young and the elderly are more vulnerable. Globalization, migration and increasing citizen mobility can all hasten the spread of infectious microbes.[14] A recent study identified a number of plausible infectious disease threats to Europe through 2020, including epidemics or tropical diseases.[15] The study also identified sexually transmitted infections as a growing concern, particularly in Eastern Europe due to the bad situation of sex workers, the lack of awareness on reproductive health, and the inaccessibility of sexually transmitted infection prevention.[16]

Other health threats for Europe may have to do with antimicrobial resistance,[17] driven by the overuse and misuse of antibiotics that characterize our modern health-care systems, mostly in the South of Europe and France.[18] The European Commission considers this an increasing health challenge to patient safety. Multidrug-resistance was already the direct cause of death of about 25.000 patients in 2007 in the EU.[19] What is more, procedures such as chemotherapies of cancer patients make these more exposed to bacterial infections, whose treatment is based on few antibiotics. Resistant bacteria could therefore impact this vulnerable, rising population of patients more heavily in the future.

For the broadly positive trends and expectations to be achieved in Europe, and in order to tackle the burden of the abovementioned NCDs, the main drivers of diseases that weigh heavily on the health of Europeans need to be addressed. The following paragraphs elaborate on their respective impacts on health.

Impacts of aging[20]

Aging increasingly characterizes the developed world, and is expected to have a major impact on the future health situation of European societies. The proportion of people aged 65 years and older has risen steadily over the past 50 years and this trend is projected to continue. This is because life expectancy is rising in Europe, while fertility rates drop. At the same time, the baby-boom generation is moving into retirement.[21] According to the European Commission, the ratio of youngsters (age group 0-14) to elderly (65 and older) was 3:1 in 1960 but is expected to be 1:2 in 2060.[22] Since the elderly are more prone to suffer from certain conditions, aging will lead to increasing health issues.[23] For example, graying societies are likely to see a rising occurrence of age-related health issues, in particular some chronic diseases.[24] The current situation in Europe is pictured in Map 2 below.[25] For each EU-country, the percentage of people over 65 is listed.



MAP 2. GEORISQ MONITOR FOR AGING: PERCENTAGES OF POPULATION OVER 65. COUNTRIES THAT STAND OUT IN DARKER SHADES HAVE THE LARGEST COHORTS OF ELDERLY (EUROPEAN COMMISSION, 2012).

The map shows a range of scores, from 11.3% of the population being older than 65 in Ireland, to almost twice the amount (20.7%) in Germany. Most European countries, however, hover around the mean of 16.3% with Central European countries generally having younger populations (e.g. Slovakia, Poland) and an 'aging belt' running from the North (Sweden) to the South (Italy and Greece), through the center of Europe.

Looking at projected European Commission data, the current situation is expected to worsen for some countries. Germany and Italy will remain the countries with the largest share of population over 65 years old, with respectively 31.9 and 31.1% of people over 65 by 2045. By 2050, Spain might outstrip Italy, with 31.6% of the population expected to be older than 65. Countries facing the highest shares of population over 65 in the next half century are however expected to be mostly eastern or central Europeans, with Latvia, Romania and Poland seeing figures rise to around 31% in 2050. It is furthermore interesting to note that countries that appear dark red in the map above will have *less* aged population than those that currently have a younger population. For example, the Netherlands is expected to see the share of its population over 65 increase from 15.3% in 2010 to 26.8% in 2050, thereby outstripping (currently higher ranking) Sweden with a projected ratio of 24.5% in the same year.

Impacts of unhealthy lifestyles

A second major factor driving health issues in Europe is unhealthy lifestyles. They include physical inactivity, unhealthy diets, smoking and excessive alcohol consumption. In spite of the increasing promotion of healthy lifestyles and preventive measures, the proportion of the European population with unhealthy habits remains at worrying levels. In this section we discuss the effects and trends in diseases that are symptomatic for modern life.[26]

Smoking weighs heavily on the health of citizens worldwide. It still accounts for increased rates of deaths associated with CVDs and respiratory diseases.[27] Even though smoking rates are decreasing in most high-income countries, cigarette consumption per capita remains typically higher than in middle- or low-income countries.[28] In Europe, the prospects are mixed. Tobacco smoking leads to 650.000 deaths in the EU per year,[29] and causes 16% of all deaths of adults over 30.[30] And though smoking in Northern

European countries is decreasing, people from lower socioeconomic strata are more likely to smoke. In Southern Europe, people start smoking or are otherwise affected by it at a very early age. For instance, in Greece children are particularly at risk given the high prevalence of smoking parents. One implication on children's health may be second-hand smoke complications or taking up the habit at a young age.[31] Such risk factors can be expected to have an impact in the longer term as well.

The WHO ranked **physical inactivity** as the fourth leading risk factor for global mortality, causing 3.2 million deaths globally. It is estimated to play a role in about one-fourth of breast and colon cancers, 27% of all cases of diabetes and 30% of all coronary artery diseases.[32] Currently, more than half of the WHO European Region does not get the recommended doses of physical activity, and according to the WHO, this share is increasing.[33] Each year, this translates into 485.000 deaths in the wider European Region.[34]

Partly–but not necessarily–related to physical inactivity is the rise of **obesity and overweight**. The latter has been increasingly linked to typical Western high-calorie diets. The EU estimates that more than half of the adult population in the EU is obese (defined as a BMI[35]>30) or overweight (defined as a BMI>25). Having a high BMI increases the chances of several diseases, particularly CVDs. Heart conditions and strokes are strongly associated with high BMIs as well. Furthermore, obesity and overweight account for almost half of all cases of diabetes, in particular type-2.[36]

Though the obesity epidemic is becoming more of a global issue, it remains a particular concern for high-income countries. As the WHO indicates, the prevalence of obesity has tripled over the last two decades in the WHO European Region, and the rates of people suffering from obesity and overweight are rising.[37] Currently, obesity and overweight are ranked fifth on the list of leading causes of death in Europe.[38]

Regarding the general disease burden, **alcohol use** is the world's third- and the EU's second-largest risk factor.[39] Although alcohol consumption has fallen in several EU Member states, it has increased in others and remains a serious threat to the health of EU citizens.[40] The average levels of consumption are now more or less similar throughout Europe, but the way

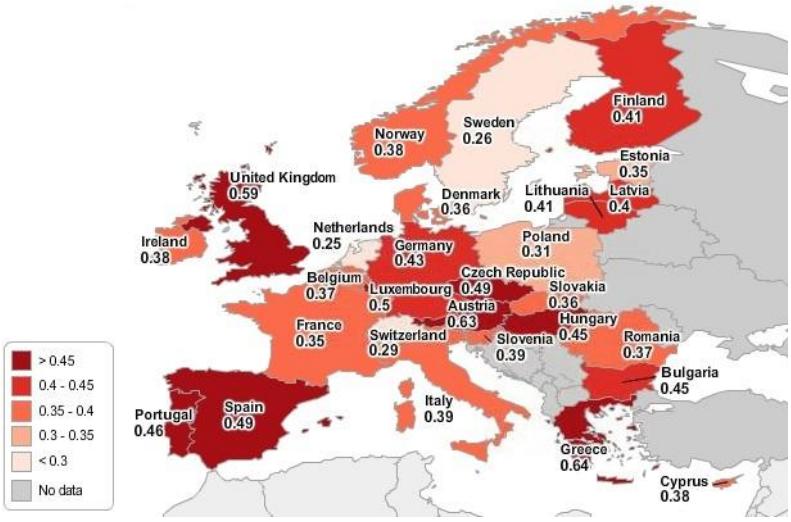
alcohol is consumed varies from one country to another. For instance, binge drinking is a pattern in the United Kingdom (UK) and in Scandinavia more so than in Italy or Spain.[41] According to Anderson and Baumberg,[42] about 195.000 deaths per year in the EU can be linked to alcohol consumption. Harmful drinking contributes to diseases such as epilepsy, CVDs, liver failure and various cancers.[43] Excessive alcohol consumption is also recognized to have serious economic effects. One report estimates that alcohol-attributable diseases, injuries and violence cost European societies around €125 billion per year.[44]

Table 1 below summarizes the number of DALYs attributed to the four major drivers of unhealthy lifestyles in high-income countries.[45]

	TOBACCO USE	ALCOHOL USE	OVERWEIGHT AND OBESITY	PHYSICAL INACTIVITY
NUMBER OF DALYS (MILLIONS)	13	8	8	5

TABLE 1. DISABILITY-ADJUSTED LIFE YEARS (DALYS) CAUSED BY UNHEALTHY LIFESTYLES IN HIGH-INCOME COUNTRIES IN 2004 (WHO, 2004)

To show the situation in Europe, we aggregated country-specific scores on smoking, physical inactivity, percentage of overweight people, and alcohol consumption. A full methodology is provided in Appendix 2.[46] Map 3 below shows the overall scores. It portrays a mottled pattern that cuts across the usual dividing lines between European states. In general, there is large variability, which seems to indicate a plethora of factors influencing the lifestyles of citizens per country. The Netherlands and Sweden stand out as countries that score particularly well, due to a good level of physical activity (in the Netherlands) and low alcohol and tobacco consumption (in Sweden). The UK, Austria and Greece score poorly in comparison. This can be explained by high alcohol consumption in Britain, and high tobacco consumption in Austria and Greece.



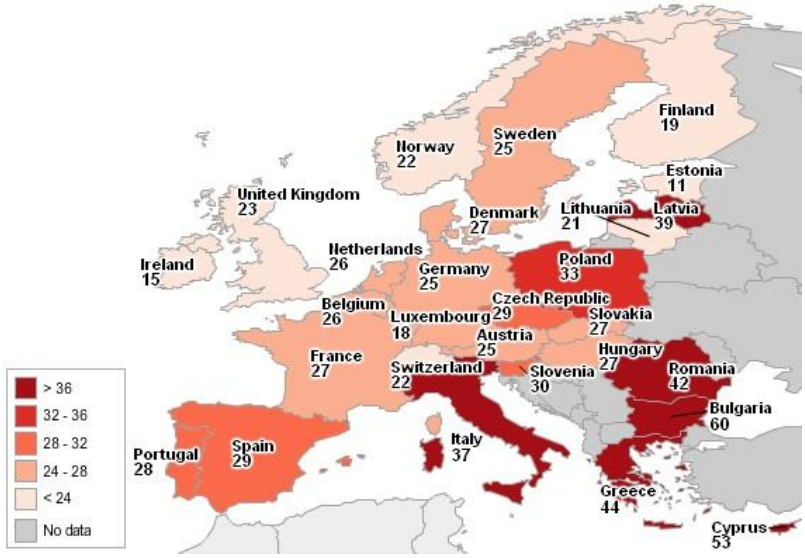
MAP 3. GEORISQ MONITOR FOR UNHEALTHY LIFESTYLES: AGGREGATE SCORE BASED ON DATA ON SMOKING, PHYSICAL INACTIVITY, OVERWEIGHT, AND ALCOHOL CONSUMPTION. DARKER SHADES INDICATE POORER PERFORMANCE.

Impacts of environmental issues[47]

A third driver of future health challenges for Europe is associated with environmental degradation and climate change. While their exact influence on health is still subjected to scientific research, both are generally recognized as major risk factors.[48] That said, looking at a global level, pollution and climate change are likely to be a more serious health issue in poorer parts of the world. Some experts even predict air pollution and related deaths to decrease in Europe.[49] Nevertheless, we find three reasons for singling out environmental issues as an important driver of future health challenges for Europe. First, as a recent OECD report points out, air pollutants lead to significant health issues in most developed countries.[50] Second, as suggested earlier, the sensitivity of European populations towards environmental risk factors has increased. People living in high-income countries are more likely to be aware of these risks and value living in an environment with minimized exposure to such factors. Third, although the long-term health effects of climate change are difficult to predict and likely to be more severe for developing world countries,[51] environmental changes may still heavily impact the health of European citizens.

One effect of **climate change** could be the increase in extreme weather events such as heat waves.[52] Such events typically affect the most vulnerable segments of the population, such as the elderly.[53] Furthermore, some organizations estimate that European countries such as France, Belgium, Spain and Portugal could see a rise in ozone-related deaths. Several authors anticipate the numbers of cardio-respiratory attacks and lethal cases of asthma to go up by 10 to 14% over the next 50 years.[54]

It is estimated that 310.000 people die prematurely each year in Europe due to **outdoor air pollution**.[55] Although the DALYs of the European populations affected by respiratory diseases are expected to decrease, air quality problems are persistent and will continue to cause significant damage to people's health.[56] Furthermore, air pollution is associated with changes in disease transmission patterns, thereby contributing to the emergence of new illnesses. It is increasingly recognized as a major factor causing certain cancers and chronic respiratory diseases. [57]



MAP 4. GEORISQ MONITOR FOR OUTDOOR AIR POLLUTION, MEASURED BY PARTICULATE MATTER (PM) IN MICROGRAMS PER CUBIC METER OF AIR (WHO, 2008). COUNTRIES THAT STAND OUT IN DARKER SHADES SUFFER FROM HIGHER EMISSIONS OF PM, AND ARE MORE VULNERABLE TO ASSOCIATED CHRONIC DISEASES.

Map 4 shows a striking division between Western European countries and Central and Eastern parts of Europe. In the latter group, air pollution scores are generally higher. This is unlikely to change soon, since pollution is rooted in the region's economic structure. The share of renewable energies used in production remains marginal in most countries that score poorly.[58] What is more, regulations are limited, and industries from wealthier European countries continue to relocate their domestic facilities to low-cost neighboring Eastern Europe.[59] Looking at national incomes, there seems to be a negative correlation between outdoor air pollution and the level of economic development. While Western European countries like Ireland or Luxembourg have the lowest levels of air pollution, the ten countries that face the most severe challenge in this respect are all Southern, Central or Eastern European.[60]

HEALTH CHALLENGES OF PROSPERITY: SOCIAL AND ECONOMIC IMPACTS

The three aforementioned drivers – aging, unhealthy lifestyles, and environmental issues – not only threaten the health of EU citizens, but also pose challenges for our economies and societies. They not only weigh on public health-care expenditure, but also decrease productivity and lead to labor shortages. Additionally, the increasing gap in the health conditions between different social classes remains a worrying trend. These impacts are discussed in the paragraphs below.

Drivers

Increasing prosperity itself paradoxically contributes to further stress on health-care systems. Below, we assess several major factors that drive the projected increases in health-care expenditure.

The rapid **graying** of European countries is likely to lead to a higher demand for health-care services. The specific effects of aging on health-care expenditure are subjected to discussions: people get older precisely because they are healthier, which may mean they enjoy better health conditions at a later age.[61] The exact health situation of the elderly is therefore difficult to predict.[62] But since most health-care costs are incurred in the final years of our lives, and aging increases the number of elderly, this is likely to translate into more health-care spending. Elderly patients often require expensive long-term care instead of generally cheaper short-term curative treatments.[63] This may drive up costs. For example, some authors

predict that the costs of treating dementias could increase by 43% through 2030, i.e. up to €250 billion for the whole of Europe.[64] Finally, while the health-care dependent share of the population will go up, the labor force and thus the tax-base will decrease due to aging and declining fertility.

Unhealthy lifestyles have a substantial bearing on public health expenditure as well.[65] For example, obesity is estimated to account for up to 7% of EU health-care costs, and expenditure will probably further increase given the rising obesity rates. Some recent studies for the US project this burden will rapidly increase in coming years.[66] In addition, 6 to 15% of the annual health-care spending in high-income countries is associated with smoking.[67]

One of the most important factor behind the rise of health-care expenditures are **technological developments and pharmaceutical innovation**. There is a widespread consensus that such advances have contributed to driving up costs, due to the availability and new demand for expensive treatments.[68] In addition, pharmaceutical and biotechnology research is increasingly costly. As an example, the costs of commercializing new drugs has risen exponentially over the last forty years.[69]

This is related to our **rising demands and expectations** about access to the best possible health-care services and treatments. As the European Commission suggests, this is likely to put additional strain on EU health-care systems.[70] Furthermore, rising costs and pressures on public expenditures may challenge the equality of access to modern health services in some Member states.[71] Health-care systems have the inherent tension between the two-fold objectives of maintaining a high degree of universal access on the one hand, and controlling health-care expenditure to preserve financial sustainability on the other.[72] For example, subsidizing health-care costs to ensure wider access may lead to the overutilization of health-care services.

Box 2 : The costs of curative and long-term health care

Cost effects are complex and differ for curative and long-term care. Studies indeed demonstrate that technological advancements do lead to cheaper curative treatments, by for example increasing efficiencies and reducing personnel costs. However, economists agree that since treatments become cheaper, and incomes increase, demand generally rises too. In some cases, this rise may outpace the drop in prices. Thereby the total spending may still increase, while costs of individual treatments decrease.[73]

Technological advances in long-term care drive up costs significantly. Unlike in curative care, productivity gains are very difficult to make. According to the so-called 'Baumol effect', labor productivity growth in long-term health care develops slower than in other sectors of the economy.[74] At the same time, wages tend to rise more than productivity gains do, because such care is more labor-intensive and less technology-dependent. As a result, the relative price of health care will be inflated, leading to higher prices for the same volume of care.[75] Finally, the relative weights of curative and long-term care are shifting. Presently, most costs are incurred in curative care. But due to aging, long-term care is likely to represent the largest part of health-care expenditure in the future.

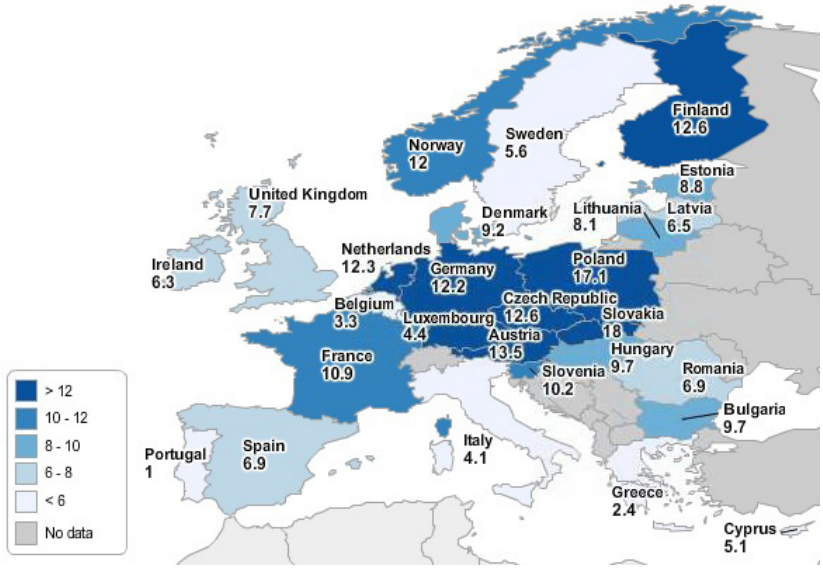
Impacts on the sustainability of health-care systems

Over the past decades, health-care expenditure in advanced economies has been steadily rising. Whereas in 1980 health-care budgets were around 5.3% of GDP in advanced economies, in 2008 this was already 7%.[76] And according to the European Commission, this increase can be expected to continue to rise from 7.1% of GDP in 2010 to 8.3% in 2060 for the EU-27.[77] This suggests coping with future health issues will be more challenging.

As a rule of thumb, the wealthier a country, the more it spends on health care.[78] Health-care costs are the main source of fiscal pressure in high-income countries.[79] In coming decades, Germany and France will remain the largest spenders as a percentage of GDP (both 9.3%) closely followed by Austria and Denmark. Sweden and the UK are predicted to see a high increase in health-care expenditure during the same period as well. With

the noticeable exception of the Czech Republic, all countries expected to top this ranking are Western European. Baltic, Southern and Eastern European countries are projected to continue to spend less than their wealthier neighbors.

Map 5 illustrates the added financial pressure health-care spending may have on government expenditures. As explained in the methodology in Appendix 3, the Monitor shows the percentual increases in health-care expenditure expected between 2010 and 2030.[80] The largest increases are anticipated for countries from central Europe, including Slovakia and Poland. These two countries are expected to see a relative increase of–respectively–18 and 17.1% in their share of GDP devoted to health-care spending, A number of Western European countries such as Austria, Finland, the Netherlands and Germany are all predicted to see a rise of more than 12%.



MAP 5. GEORISQ MONITOR: RELATIVE INCREASE IN HEALTH-CARE EXPENDITURE BETWEEN 2010 AND 2030 (EUROPEAN COMMISSION)

Beyond the drivers already mentioned, there may be other factors influencing health-care expenditure projections. Obviously, some countries have large expenditure-reducing reforms in place that limit projected spending increases (for instance, in Luxembourg).[81] And lower than expected GDP growth is often not followed by adjusted health expenditures. Finally, some relatively small projected increases can be explained by the high fertility rates, such as in Portugal.

Impacts on labor markets

Apart from threatening the sustainability of health-care systems, aging and unhealthy lifestyles also have other negative economic effects. In particular, these two factors put downward pressure on productivity levels, and are likely to lead to labor shortages in certain sectors of the economy.

First, chronic diseases lead to **premature mortality** (87% in the EU) **and loss of productiveness** through early retirement, higher job turnover and disabilities.[82] A report by the World Economic Forum (WEF) notes that half of those dying from chronic diseases were in their economically productive years. This issue has considerable social costs and economic consequences in terms of human capital and productivity losses.[83] These indirect costs of chronic diseases can be much higher than the direct health costs for countries. The WHO estimates for example that between 2005 and 2015, income loss caused by chronic diseases could rise to as much as $33 billion in the UK alone.[84]

To get an idea of the economic impact of chronic diseases, we look at a recent study by the WEF and the Harvard School of Public Health. This report estimates the total economic costs of NCDs for countries at different income levels (see Table 2 below).[85] It looks at five of the biggest groups of NCDs: cardiovascular diseases, cancers, mental illnesses, diabetes and chronic respiratory diseases. The aggregate economic impact of NCDs over the period from 2010 to 2030 is expected to be especially severe for high-income countries. Three groups of diseases stand out: mental illnesses, whose costs are estimated to be $9 trillion, CVDs ($8.5 trillion), and cancers ($5.4 trillion).

COUNTRY INCOME GROUP	DIABETES	CARDIO-VASCULAR DISEASES	CHRONIC RESPIRATORY DISEASES	CANCER	MENTAL ILLNESS	TOTAL
High	0.9	8.5	1.6	5.4	9.0	25.5
Upper-middle	0.6	4.8	2.2	2.3	5.1	14.9
Lower-middle	0.2	2.0	0.9	0.5	1.9	5.5
Low	0.0	0.3	0.1	0.1	0.3	0.9
Low and Middle-Income Countries	0.8	7.1	3.2	2.9	7.3	21.3
World	1.7	15.6	4.8	8.3	16.3	46.7

TABLE 2. ECONOMIC BURDEN OF NCDS, 2011-2030 IN TRILLIONS OF US$ (WEF AND HARVARD SCHOOL OF PUBLIC HEALTH, 2011)

Box 3: Global economic effects of NCDs

NCDs are by no means of singular European concern. Such diseases are a global health challenge that cause more than 60% of deaths worldwide. The WEF expects that by 2030, NCDs could be the leading cause of death in all regions worldwide. In 2010, it was anticipated that chronic diseases may increase up to 2020 by 27% in Africa, 25% in the Middle East and 21% in Asia and Pacific.[86] At the same time, there is good reason for stressing the particular concern of NCDs in developed countries. First, the leading causes of death and ill-health in high-income countries are all NCDs. Second, the burden of disease attributed to NCDs is more significant in Europe than in poorer countries, where communicable diseases have a much larger effect on the overall health situation.[87] In contrast, such diseases affect European societies much less, both in absolute and relative numbers.

Second, graying societies are expected to lead to *a shrinking labor force*.[88] On the one hand, more elderly retire, which may cause scarcity of human capital and skills in some sectors, and inadequate means of health-care delivery. Indeed, the health-care sector itself may experience difficulty in attracting people to provide sufficient care to an increasing number of

patients. The OECD anticipates the demand for health-care workers, especially for long-term care, to double in most OECD countries in the coming decades.[89] And the European Commission expects that about one million health-care positions will be unfilled in the EU by 2020.

Health inequalities

Another potential challenge facing EU countries concerns the unequal distribution of health problems. As noted before, most chronic conditions, mental health problems and disabilities are more prevalent among those of lower socioeconomic status.[90] At country level, there seems to be a moderate negative effect of inequality on the health of the whole population.[91] When looking at income groups itself, health inequality is closely related to health status. What is more, as shown in the paragraphs below, the health gap between socioeconomic classes is increasing.

Generally, the lower an individual's educational level and income, the lower his or her life expectancy and the more health problems he or she is likely to suffer from.[92] First, the *mortality* rate differs significantly. A 2007 report by the European Commission points out that in the EU-25, health inequalities lead to a reduction in life expectancy of 1,84 years.[93] Second, *unmet health needs* are much more likely to occur among those with lower incomes.[94] A third difference over socioeconomic classes lies in *morbidity rates.* The same report from the European Commission estimates that health inequalities lead to a reduction in the total years in good health of 5,14 years.[95]

There is a strong correlation between income and health at different levels. First, as shown in the Monitor on 'The Health of Nations' (see Map 1), a country's GDP is a good proxy for overall health situation of its citizens. Second, high income inequalities *within* a region or a country negatively affect health.[96] This is particularly relevant for the developed world, with income inequality significantly increasing in the majority of OECD countries.[97] Third, studies show that individual income effects health.

Poor health associated with lower socioeconomic status tends to be more typical of countries characterized by greater income inequalities rather than within more equal countries.[98] These elements are relevant to the developed world, which has experienced a growing gap between its rich

and its poor populations throughout the past decades.[99] The rising gap in mortality rates between socioeconomic groups in Europe is a case in point.[100] And as a 2012 study on Finland shows, the growing gaps in life expectancy could be mainly explained by the stagnation of mortality among populations with lower incomes.[101]

There is further evidence that socioeconomic status influences an individual's health situation. There appears to be a strong correlation between unemployment and increased numbers of heart attacks, mental health problems, unhealthy behaviors, as well as reduced access to health care.[102] This suggests that the current economic crisis may exacerbate health issues for those groups that are particularly hard exposed (see Box 4 below). With unemployment on the rise and more people seeing their income decline, this could well lead to a spread in unhealthy behavioral patterns discussed in this chapter, which will constitute yet another burden on Europe's public health systems.[103]

Box 4: The economic crisis and health inequalities

Could the current economic downturn exacerbate socioeconomic differences in Europe – and hence health inequalities? Falling incomes and austerity measures are likely to limit the accessibility of health care. At the same time, rising unemployment rates are closely associated with increased numbers of heart attacks, mental health problems and risky behaviors such as consumption of tobacco and alcohol, as well as reduced access to health care.[104] In addition, high(er) health-care costs is a major reason for adults with lower socioeconomic status to put off visits to a practitioner or a specialist.[105]

Socioeconomic impacts of health and health-care trends may not only be reflected in the state of our economies and health of citizens, but also lead to increased political instability. As a result of the challenges mentioned in this chapter and in order to offset the risk of future fiscal crises, advanced economies are likely to be forced to reform their social security systems and implement unpopular decisions in times of economic hardship. As noted by the WEF, this may result in political instability and tensions, thereby challenging societal security.[106]

1.4 CONCLUSION

The first chapter of this report yields several conclusions.

Although the overall health situation of European countries is good, this region faces specific health challenges.

Such health challenges of prosperity emerge because of four dynamics:

- Increasing wealth is associated with certain health risk factors;
- with wealth, health expectations shift;
- medical knowledge has broadened;
- certain health issues are more costly for developed countries, since they weigh heavily on productivity.

Three drivers are particularly important in identifying the diseases that will likely form a future health challenge for Europe: aging, unhealthy lifestyles, and to a lesser extent environmental issues. Combined, they are expected to **increase the burden of non-communicable diseases**. Cancers, cardiovascular diseases, mental disorders, and to a lesser extent diabetes and respiratory diseases are expected to impact the health of Europeans. All remain the largest source of healthy life years lost. As causes of death, most will increase; increase in relative importance; and some diseases such as dementia's and certain cancers are predicted to increase in absolute terms.

The sustainability of health-care systems is pressured by a number of factors. Here again, aging and unhealthy lifestyles, but also technological innovations, rising expectations and the economic crises will increase costs and health-care demand. Simultaneously, the tax base and labor supply will decrease. The Netherlands, Germany and several Central and Eastern European countries are particularly expected to face relative steep relative increases in public health-care expenditure.

Mental illnesses, CVDs and cancers are projected to have a severe negative economic impact in high-income countries. Such diseases may exacerbate labor shortages and affect labor productivity.

In the coming years, aging is expected to lead to a **shift in demand from curative to long-term health care**. This is especially concerning since productivity gains (for example enabled by technological innovations) are difficult to make in the labor-intensive long-term care sector.

Health inequalities are expected to remain a source of concern for Europe. Especially personal income impacts the health of Europeans. The concentration of lower life expectancies in lower social strata shows the importance of targeting health problems among people in those groups.

The economic crisis and associated slowing or negative growth may put further strains on already rising health expenditures. Combined with the trends outlined in this chapter, this may also lead to more **social instability**.

The question then is: how can we tackle these health challenges? Obviously, much of how well we will be able to cope depends on policies that incentivize people to live more healthy lives, cut back pollution and address the needs of lower socioeconomic classes. But research has a big role to play as well, by gearing R&D towards tackling societal health challenges. Before we look at specific areas of research and paradigm shifts that can support this ambition, we give an overview of ongoing research in health (care) in the second chapter. This may help in spotting possible gaps in R&D focus and funding, as well as providing an overview of the global health research hotspots.

2 ONGOING HEALTH RESEARCH

2.1 INTRODUCTION

This chapter shows to what extent science, technology and innovation focus on the challenges identified earlier. This serves the two-fold purpose of, first, mapping the international and European research landscape and second, identifying the research areas that are more or less emphasized.

There are different ways to look at health research.[107] One often-used classification is based on disciplines, usually distinguishing between life sciences research and public health research. The latter focuses on population and organizational health issues. Life sciences research is divided up in biomedical (laboratory) and clinical research (involving patients).

Here, we base the main thread of this chapter on another categorization of research areas that connect to Europe's major health challenges. These areas can be summarized as follows: (i) research on the drivers of health challenges of prosperity; (ii) research on chronic diseases, specifically those of mental health issues, CVDs and cancers; and (iii) health research on economic and social issues (see Figure 2 below).

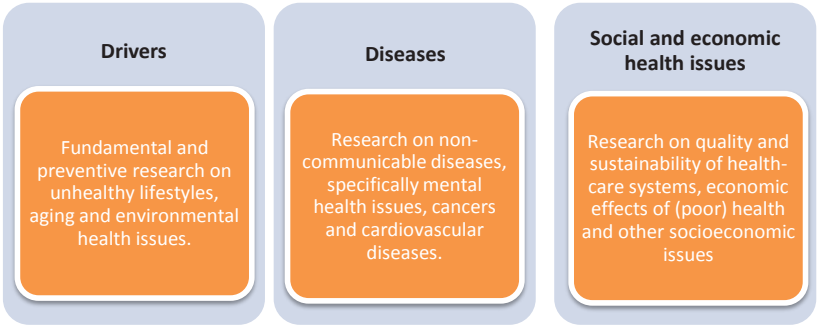


FIGURE 2. THREE RESEARCH AREAS THAT CONNECT TO THE FUTURE HEALTH CHALLENGES FOR EUROPE

The chapter starts with a section presenting an overview of the main health research actors. We look at funding from private and public actors and to what extent this connects to the three research areas mentioned above. Thereafter we look at countries of excellence. Using bibliometric data, we identify countries where most research is conducted.

2.2 ACTORS

In this section, we first examine health research at a country level, particularly among EU Member states. Second, we investigate the different relevant health research programs of the EU itself. A third paragraph surveys the importance of private sector health research.

EU MEMBER STATES

What do governments spend on health R&D and what is the focus of this research? Looking at direct public health-care expenditure, EU governments spend generally less than the US on health R&D. But when looking at indirect health research funding, the picture changes somewhat. Figure 3 below shows that Austria and Sweden spend significantly more than other countries on *indirect* health research such as 'advancement of knowledge' in medical sciences (for instance funding of R&D activities in universities) and 'other funding' (which refers to more general R&D support on health, such as research budgets for hospitals). Austria, Sweden, as well as a range of other European countries such as Finland, the Netherlands, France and Germany, also spend much more on medical sciences research than on direct health research. This is less so the case in Spain, Italy, Denmark, the UK, or Estonia. In general, Northern and Western European countries seem to spend much more on health R&D.

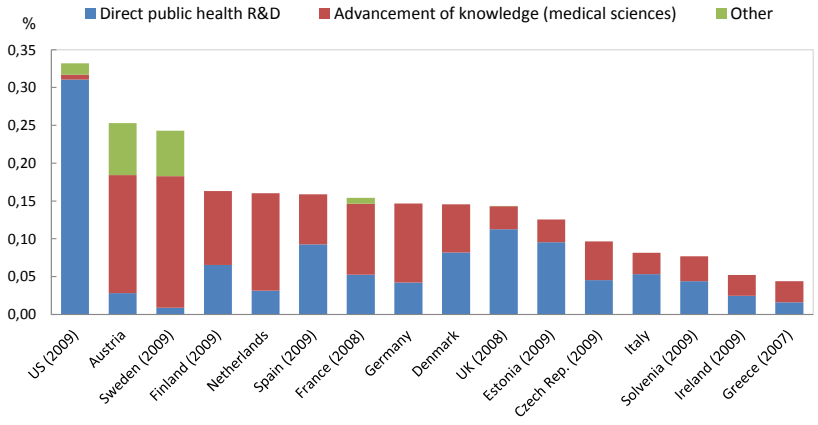


FIGURE 3. PUBLIC FUNDING OF HEALTH-RELATED R&D, 2010 AS A PERCENTAGE OF GDP (OECD, MAY 2011)

17 of the 27 EU member states refer to health research in their **national R&D strategy** in 2010. Only the Czech Republic, Germany, Ireland, Italy and the UK have a *specific* national health research strategy (see Box 5), with the Netherlands also addressing health research in an overarching research strategy.[108] France, Denmark and Sweden do not have a national health research strategy, but have a research strategy in place for their national health agency. Such health research strategies are especially lacking in Eastern European countries.

Box 5: Encompassing health R&D strategies in the UK and Germany

The UK and Germany have initiated multidisciplinary strategies to guide their R&D health policy. Both countries seek to combine public and private sector efforts and improve cooperation between industry and science. Aging populations and a desire to further optimize their respective health-care systems lay at the origin of these efforts.

The **German** R&D health strategy is based on the *High-tech strategy 2020* which was launched in 2006. The strategy promotes research into existing major age-related diseases.[109] It also pays attention to unhealthy lifestyles and singles out "an optimized diet" as a primal concern. In the *Roadmap for the German Health Research Program*,

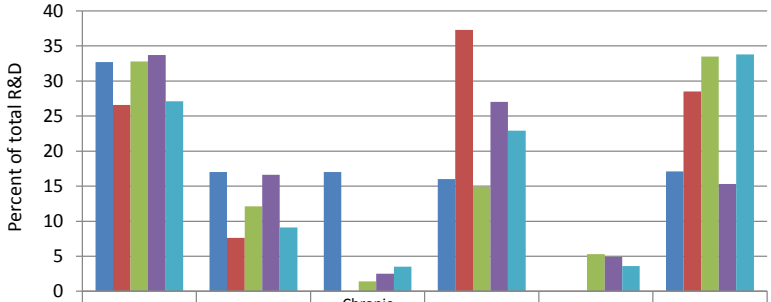
which was published a year later, the Federal Government prioritizes research on six core diseases: musculoskeletal disorders, nutritional and metabolic diseases, CVDs, infections, cancers, and mental illnesses.[110] It also encourages the internationalization of health research by "joint developing research infrastructures", in particular with developing countries and on neglected and poverty-related diseases.

The Health Research Framework which was launched in 2010 identifies several health research priorities, including research on major diseases, individualized medicine, prevention and nutrition, and health-care systems.[111] The framework suggests a link between ensuring good health and attributing importance to economic and social health issues. The need for international cooperation in health research is also emphasized.

The **British** Health research strategy is based on its *Strategic plan 2009-2014*. The plan is drafted and executed by the British Medical Research Council, a government agency responsible for funding research. It defines four strategic aims: the improvement of health outcomes through research; bringing the benefits of research to all sections of society; internationalize health research; and supporting scientists for "world-class medical research".[112] These goals are deemed necessary in order to deal with diseases, in particular the large amount of NCDs, and drivers, including population aging and the effects of environmental changes on health. This underscores that in the UK too, research on socioeconomic health issues receives quite some attention.

One interesting element of the R&D health program of the UK is the 'Clinical Research Collaboration' created in 2004.[113] The organization aims at improving the clinical research environment and brings together public and private actors. The large majority of funding is equally concentrated on environmental, psychological, biological and socioeconomic drivers of diseases as well as in the cause, detection, treatment or management of diseases and public health research. Public health research on disease prevention and research investigating health and social-care systems are attributed a smaller part of the funding. For prevention, research focuses on diet and nutrition, physical activity and alcohol, tobacco and drugs.

To get an idea of the specific **research focus on diseases at country level**, we use a study published by the WHO. It reveals the various research priorities in 2008 of five OECD countries, including three EU Member states (see Table 3).[114]



	Cancer	Cardiovascular Disease	Chronic Respiratory Disease	Mental Health	Diabetes	Communicable Disease
France	32,7	17	17	16		17,1
Germany	26,6	7,6		37,3		28,5
Japan	32,8	12,1	1,4	14,9	5,3	33,5
United Kingdom	33,7	16,6	2,5	27	4,9	15,3
United States	27,1	9,1	3,5	22,9	3,6	33,8

TABLE 3. PROPORTION OF PUBLIC R&D FUNDING BY DISEASE AND BY COUNTRY (WHO, 2009). NOTE: RESEARCH ON DIABETES IS INCLUDED IN CVD RESEARCH, IN FRANCE; DATA ON DIABETES AND CHRONIC RESPIRATORY DISEASE RESEARCH IN GERMANY ARE NOT AVAILABLE.

Overall, diabetes and chronic respiratory diseases receive much less funding, with a concentration of research efforts on cancers, CDs and mental health issues. Among the five countries, large differences are visible. Chronic respiratory diseases receive a much larger amount of research funding in France than in other countries. Most of France's health research expenditure is geared towards cancer research. The same holds for the UK, which also allocates more than a quarter of R&D funds to mental health issues. Germany is the exception with most research focusing on mental health issues and less on cancers and CVDs. In addition, more than 25% of funds is spent on CDs research. The US and Japan even spend more on CDs than in any other field. The US further focuses its research on cancers, followed by mental health issues (both around 25%). Research in Japan is

heavily concentrated on cancers as well, and to a lesser extent on mental health issues (the lowest funding of the five countries with 14.9%) and CVDs (12.1%).

THE EUROPEAN UNION

Apart from national research activities in Europe, the EU is funding a wide range of health R&D projects. Below we look at some of the most important ones in more detail.[115]

Health research in FP7

Within the different EU Framework Programs (FPs) that fund research projects in the EU, health has become a major priority. Under the current FP7, which runs from 2007 to 2013, health was classified as one of eleven separate themes for the first time. In total, health is allocated a budget of over €6.1 billion, the largest of all research themes.[116] It is made up of three major 'pillars':[117]

1. The first pillar **'Biotechnology, generic tools and medical technologies for human health'** focuses on the detection, diagnosis and monitoring of illnesses, and the prediction of the safety and efficacy of therapies. It also funds innovative approaches such as gene therapy or regenerative medicine.

2. **'Translating research for human health'** looks chiefly on major NCDs.

3. **'Optimizing the delivery of health care to European citizens'** consists of four activities, namely clinical research into practice; health systems research; health promotion and disease prevention; and international public health and health systems.[118]

Within each of the three pillars, health research is funded and conducted through a number of projects. These include those supported in six initiatives called 'Thematic Domains': medical research; infectious diseases; public health; large scale data gathering and systems biology; biotechnology, tools and technologies; and innovative medicines initiative. Table 4 below provides a summary and includes budgets where available.

1. Biotechnology, generic tools and medical technologies for human health	n/a
Focus: High-Throughput Research; Detection, diagnosis, monitoring; Predicting Suitability, Safety and Efficacy of Therapies; Innovative Therapeutic Approaches and Intervention	
• Thematic domain: Innovative Medicines Initiative	**€600m**[119]
• Thematic domain: Biotechnology, Tools and Technologies, including:	n/a
Biomedical Technologies	€220m[120]
Diagnostics and Imaging[121]	n/a
New Therapies and Immunization Strategies (including Neurodegenerative Diseases, Tropical Diseases and Respiratory Diseases[122]*)*	n/a
Alternative testing strategies	€25m[123]
2. Translating research for human health	n/a
Focus: Integrating biological data and processes, including large scale data gathering and systems	
• Corresponding thematic domain: Large-scale data gathering & Systems Biology, including:	n/a
Omics	€570m[124]
Biobanks and Population genetics	n/a
Model Organisms	€150m (FP5, FP6)[125]
Systems Medicine	€400m (FP6, FP7)[126]
Focus: Research on the brain and related diseases, human development and aging; Translational research in major diseases	
• Corresponding thematic domain: Medical Research, including:	**€967.8m**
Health and Aging	€115m[127]
Brain Research including Neurodegenerative Diseases (including Dementia, Parkinson and Alzheimer's)	€194m[128]
Cancer	€240m[129]
Cardiovascular Diseases	€163m[130]
Diabetes and Obesity	€123m[131]
Rare Diseases	n/a
Severe Chronic Diseases, including Asthma and Other Respiratory Diseases	€132.8m[132]
Focus: Translational research in major infectious diseases	
• Corresponding thematic domain: Infectious Diseases, including:	n/a
Antimicrobial Drug Resistance	
Poverty-Related Diseases (HIV/AIDS, Malaria, Tuberculosis)	
Potentially new and emerging epidemics	
Neglected Infectious Diseases	
3. Optimizing the delivery of health care to European citizens	**€275m**
• Corresponding thematic domain: Public Health, including:	
Translating Clinical Research into Practice	€67.5m[133]
Health Systems Research (Quality, Efficiency and Solidarity of Healthcare Systems including Transitional Health Systems)	€63.5m[134]
Enhanced Health Promotion and Disease Prevention including Health and Aging and Unhealthy Lifestyles	€47m[135]
International Public Health and Health-care systems	€97m[136]

TABLE 4. HEALTH RESEARCH UNDER FP7: BREAKDOWN OF ACTIVITIES FUNDED, AND 2007-2013 BUDGET ALLOCATIONS (N/A IF NOT AVAILABLE, BETWEEN BRACKETS IF OVER DIFFERENT PERIOD)

How does FP7 research relate to the three research areas that connect to Europe's future health challenges? Looking at the projects listed in the table above, some general patterns can be observed.

- Regarding **drivers**, 'health and aging' was allocated a budget of €115 million. Furthermore, under the third pillar, there is a specific though modest budget available for research on health promotion and disease prevention, with a particular focus on aging and unhealthy lifestyles.

- The five **NCDs** that were singled out as potentially most costly for Europe were allocated relative large sums of funding, with cancer research receiving the greatest share (€240 million), followed by brain research (€192 million) and CVDs (€163 million). Diabetes and obesity, and other chronic diseases such as asthma and other respiratory diseases follow with €123 and €132.8 million. In the first chapter, we show that the economic burden of mental health issues would be the heaviest for high-income countries, followed by CVDs.

- Finally, a modest share of the funding is directed towards the optimization of health-care delivery. This suggests a more limited involvement of the EU in (directly funded) **public health research**. In total, it is allocated €275 million, which represents about 4.5% of FP7 health's budget. Overall, the budget allocation indicates a clear focus on sustainability of health-care systems. The enhancement of *health promotion and disease prevention* receives a much smaller share of the budget.

Another observation is that '**systems medicine'** has received €400 million in funding under FP6 and FP7 from 2004 to 2010. Systems research stresses the importance of a more integrated approach towards medical research, that makes use of different specialized knowledge and methods in an otherwise fairly fragmented research landscape.[137]

To have an indication of how these pillars may develop in the near future, it is interesting to briefly elaborate on the next Framework Programme, **Horizon 2020**,[138] which will start in 2014 and end in 2020. The program will address six societal challenges, including the 'health, demographic change and wellbeing challenge', with a budget of €9 billion for the period 2014-2020. Thus aging and health are combined in one societal challenge. The research theme is divided into three categories: (i) health promotion and

disease prevention, (ii) curing, treating, managing disease, disability and reduced functionality, and (iii) sustainable and efficient health-care systems. Interestingly, this is very much in line with the three research areas we identified earlier, namely drivers, diseases, and social and economic health issues.

Other EU health research

Apart from research funded under the health theme of FP7, there are several research programs within and outside FP7 that focus on health.

As shown in Table 5 below, some **other FP7 research themes** that can be associated with health: in the fields of ICT, nanosciences, environment and food. Many of these connect to the drivers of health challenges of prosperity: aging, unhealthy lifestyles and environmental issues. The focus is strongly on developing preventive measures that curb the negative health impacts of these three drivers.

RESEARCH THEME AND RELEVANT SUB-THEME	DESCRIPTION
ICT: ICT FOR HEALTH, AGING WELL, INCLUSION AND GOVERNANCE[139]	Research addresses the management of health, including remote management of diseases, treatment and rehabilitation, the development of models and simulation of major diseases, integrating medical, biological and environmental data and services for the personal management of health. Focus is on empowering dependent people (i.e. elderly or disabled) and enhance independent living through solutions that combine health, social care and smart living systems.[140]
NANOSCIENCES: NANOSCIENCES AND NANOTECHNOLOGIES	The main objective is to support the scientific assessment of the potential health, safety and environmental risks associated with nanotechnology-based materials and products.[141]
ENVIRONMENT: ENVIRONMENT (INCLUDING CLIMATE CHANGE)	The sub-area focuses on three priorities: health impacts of climate change, health effects of other environmental stressors and methods and decision-support tools for environmental health risk analysis and policy development.[142] Specific research focus points are the influence of risk factors such as air quality (indoor and outdoor), the urban environment and car emissions.[143]
FOOD: FARM TO FORK – FOOD (INCLUDING SEAFOOD), HEALTH AND WELLBEING[144]	Food has an enormous influence on our health. The easy availability of food products and sedentary lifestyles have generated increased rates of obesity, diabetes and CVDs among European societies.[145] Here research is focused on consumer behavior, nutrition, and food quality and safety.

TABLE 5. HEALTH RESEARCH IN OTHER FP7 RESEARCH THEMES AND THEIR RELEVANT SUB-THEME

Other important research programs and projects focusing on health are developed independently from FP7. The most important ones are listed in the box below. Many focus on aging and, to a lesser extent, unhealthy lifestyles. The major NCDs identified in the first chapter (cancers, CVDs, and neurodegenerative disorders) again stand out as main focus areas. It is also interesting to note the attention paid to social and economic issues such as research on social inclusion and health equality.

Box 6: Other EU-funded health research

The current **EU Health Program** (2008-2013) is the European Commission's main instrument to implement the EU Health Strategy. The program includes scientific and technical projects, which are supported in three key themes: (i) improving citizens' health security; (ii) promoting health and reducing health inequalities; and (iii) generating and disseminating health information and knowledge.[146] The greatest number of projects deal with health promotion,[147] with a specific focus on aging and (un)healthy lifestyles.

Within the **Competitiveness and Innovation Program** (CIP), specific emphasis is placed on *ICT for Health, Aging Well and Inclusion*, to which €27 million has been allocated.[148]

The **European Innovation Partnership on Active and Healthy Ageing** conducts research on prevention and early diagnosis, care and cure, active aging and independent living, with a focus on age-related diseases such as dementias.[149]

The ICT Labs of the **European Institute of Innovation & Technology** (EIT) are involved in the development of innovative products and services that aim to develop self-management in health.[150] They are one of the Knowledge and Innovation Communities of the EIT, whose purpose is to accelerate innovation in Europe.[151]

Two **European Technology Platforms** (ETPs) address health-related issues. The first, *NanoMedicine*, focuses on nanotechnology-based health care and research on nanomedicine, in order to tackle illnesses such as cancers, CVDs, Alzheimer's and Parkinson's diseases, diabetes,

and various infectious diseases.[152] The second, *Net!Works*, includes a program on mobile technologies in health, with a specific emphasis placed on (un)healthy lifestyles and aging, and on social inclusion issues as well.[153]

In addition, the EU is funding other research activities on socioeconomic health issues. For example, ensuring the rights of persons with disabilities is the main subject of a range of research projects. In particular, the **European Agency for Safety and Health at Work** communicates the outcomes of research concerning priority groups that include aging workers and people with disabilities. Subsidies from the European Commission have consistently increased since 2005, which suggests a stronger commitment towards such issues.

PRIVATE SECTOR

In high-income countries, most health R&D comes from the private sector. In 2005 (most recent figures) the private for-profit sector was the largest investor with about 50% of all health R&D funding. The not-for-profit private sector, which has been increasingly investing in health research, funded 8% of the total amount. The rest was accounted for by the public sector.[154]

The dominance of the private sector becomes even more evident when looking at **research on diseases** – the main priority of private sector research. The pie charts in Figure 4 paint a general picture of private and public research funding on NCD and CDs for France, Germany, Japan, the UK, and the US. These countries serve as a good example: collectively, they are home to the largest private sector health-care industry in terms of revenues and spending.[155]

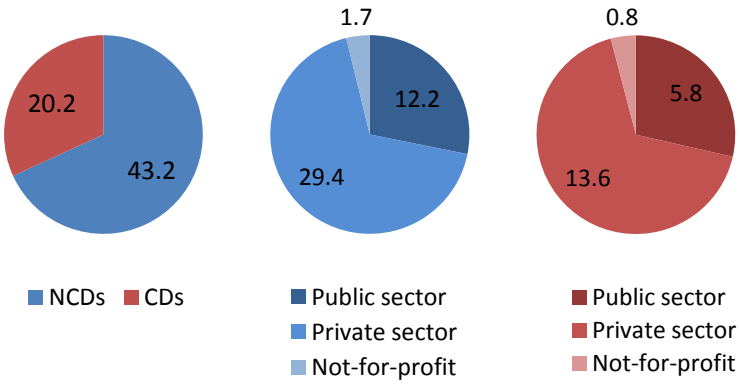


FIGURE 4. R&D INVESTMENTS IN DISEASES IN BILLIONS OF $ IN 2008, IN FRANCE, GERMANY, JAPAN, THE UK AND THE US (WHO, 2009). THE FIRST PIE CHART GIVES A GENERAL OVERVIEW, AND THE TWO OTHER PIE CHARTS SHOW THE BREAKDOWN OF INVESTORS BY DISEASE TYPE.

The pie-charts above show that private sector health research expenditure in the five selected countries for health in 2008 accounts for more than twice the total amount of public R&D investment on diseases. A much smaller amount of research is sponsored by the not-for-profit sector. In total, about two-thirds was allocated to NCDs and one-third to CDs.[156] Interestingly, this roughly corresponds to one estimate of the global economic burden of diseases.[157]

The most important industries in the private (for-profit) sector in terms of influence and investment are multinational pharmaceutical firms and medical devices companies.[158] Below we look at these sectors in more detail.

The pharmaceutical industry

The European research-based pharmaceutical industry invested nearly €28 billion in health R&D in 2010, which was more than Japan (€12.8 billion) but less than US companies, which had spent nearly €41 billion.[159] When looking at country specific R&D investment, latest available figures are from 2006. As the figure below shows, pharmaceutical industry in European countries spent relatively more in terms of percentage of GDP than the US, with Denmark topping the chart with close to 0.5%.[160]

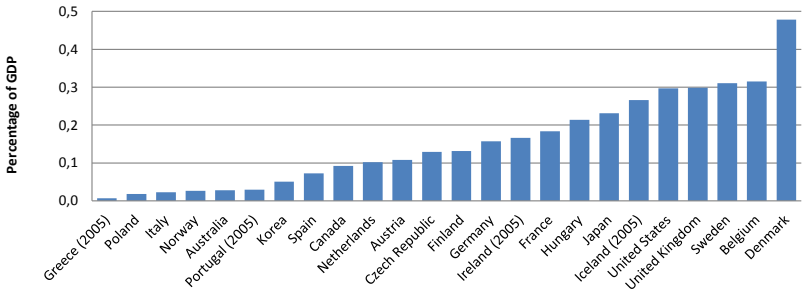


FIGURE 5. R&D EXPENDITURE IN THE PHARMACEUTICAL INDUSTRY AS A PERCENTAGE OF GDP IN 2006 (OECD, 2009)

If we consider total private sector health R&D expenditure of the pharmaceutical research industry, we see six European companies in the top-10.[161] This is reflected in Table 6 below, which provides a rough picture of the research expenditures and total number of projects in communicable, non-communicable and other diseases.[162]

COMPANY AND COUNTRY OF ORIGIN	R&D BUDGET IN $ BILLION ADJUSTED TO PPP IN 2008	COMMUNICABLE DISEASES (IN NUMBER OF PROJECTS)	NON-COMMUNICABLE DISEASES (IN NUMBER OF PROJECTS)	OTHER DISEASES*** (IN NUMBER OF PROJECTS)	COMPANY TOTAL NUMBER OF PROJECTS
JOHNSON & JOHNSON* (US)	8.4	n/a	n/a	n/a	
PFIZER (US)	7.9	11	60	29	100
NOVARTIS** (SWITZERLAND)	6.1	17	29	4	50
GLAXOSMITH-KLINE (UK)	5.6	8	51	77	136
ASTRAZENECA (SWEDEN/UK)	5.2	10	53	13	76
SANOFI-AVENTIS (FRANCE)	5	19	31	14	64
MERCK (GERMANY)	4.8	5	39	3	47
ELI LILLY (US)	3.8	0	53	13	66
AMGEN (US)	2.9	0	24	16	40
ROCHE (SWITZERLAND)	2.5	4	69	13	86
TOTAL R&D BUDGETS	52.2	74	409	182	579

* J&J does not provide the total number of projects developing drugs per category
** Novartis reports details for only 50 out of their total of 152 projects
*** The source does not provide information on what is included in 'Other diseases'

TABLE 6. NUMBER OF ACTIVE DRUG DEVELOPMENT PROJECTS BY CATEGORY IN $ BILLION ADJUSTED TO PPP (WHO, 2008)

Global spending on medicines is expected to grow through 2016, yet at a much slower pace in developed markets, due to an unprecedented number of patent expiries on older medicines or slower spending on branded products as more generic products are launched.[163] Furthermore, data shows that the US clearly dominates the pharmaceutical market.[164] While the US developed a total of 3.091 medical compounds in 2011, Europe developed 1.449.

Obviously, research by pharmaceutical companies is **commercially driven**. This may partially explain heavy focus on curative medicine, due to a lack of commercial incentives supporting innovation in preventive or long-term care medicine.[165] In general, it may 'divert' research from health challenges of prosperity to some extent. In 2011 for example, the majority of medicines in development in the US market were targeted at cancer (27%), followed by respiratory diseases (11.1%), mental and behavioral disorders (7.2%), and CVDs (7.1%). A lower number of medicines were developed for diabetes (5.8%) and dementias (2.8%).[166]

One report that looks at **future prospects** anticipates that pharmaceutical companies will further invest in therapies for cancers, respiratory diseases, diabetes and CVDs.[167] Pharmaceutical companies focus heavily on cancers and less on (other) diseases which are expected to become as much of a problem for European societies. CVDs, diabetes and to a lesser extent mental health research receive less funding. This is reflected when looking at drugs in development and testing phase. While 861 new medicines for cancer are in this phase, the numbers for other diseases such as diabetes, CVDs and mental health disorders are much lower (235, 312 and 313 trials respectively).[168]

R&D funding and projects are one thing, translating research into applicable medicine quite another. To get an idea of the latter, we looked at worldwide **patent applications**. Figure 6 below shows the total pharmaceutical patent applications filed at the World Intellectual Property Organization (WIPO) for four world regions as a share of total patent applications for these regions. It makes clear that the US is most productive in filing pharmaceutical patents, and much more so than EU-27 countries. Within Europe, most pharmaceutical patents between 2007 and 2009 were filed by companies based in Germany, the UK and France.

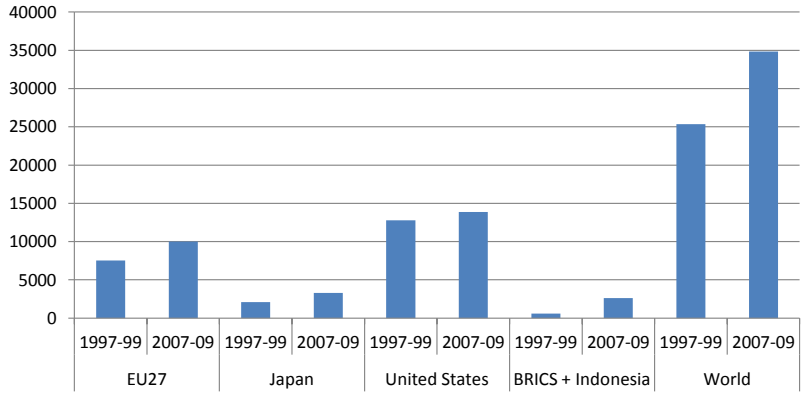


FIGURE 6. NUMBER OF PHARMACEUTICAL PATENT APPLICATIONS FILED AT THE WIPO UNDER THE PATENT COOPERATION TREATY OVER THE YEARS 1997-1999 AND 2007-2009 PER REGION (OECD, 2011)

Box 7: Examples of private pharmaceutical research

In 2012, **Roche Holding AG's Genentech** Research and Early Development (Switzerland) has started to trial a new experimental Alzheimer's drug, Crenezumab, on people showing no signs of dementia. It is the first such trial to assess whether early spotting and intervention can help prevent or mitigate the disease.[169]

For diabetes, the research on SGLT-2 drugs (a new class of medication), is accelerating. This year, Eli Lilly (US) and **Boehringer Ingelheim (Germany)** have presented the results of a new SGLT-2 drug, Empagliflozin, which would lead to reduced body weight and lower blood glucose.[170]

Medical devices companies

Medical instrument (or 'medtech') companies form the second most research intensive health-care industry. This very heterogeneous sector develops devices as diverse as respiratory circuits, blood glucose monitors, hearing aids, wheelchairs or radiation devices.[171] R&D investments are concentrated chiefly in the US, followed by the EU and Japan. The R&D expenditure of the medical device industry in the EU and Switzerland amounted to $500 million in 2006.[172] Germany, the UK, France and Switzerland are home to the most powerful 'medtech' firms in Europe.

Most **European companies** are involved in developing therapeutic equipment.[173] This field of research is focused on disease treatment and looks at the development of orthopedic and cardiovascular devices primarily.[174] Two other important types of devices developed by medtech companies are non-imaging diagnostics (e.g. devices detecting irregular heart beats, breath tests, etc.) and imaging (such as X-rays). The former is attracting more and more investments, which could mean that the industry is developing more devices aiming to prevent or detect health risk factors.

Future prospects for medtech companies look promising. Indeed, growing demand for relevant products and services, such as assisted living technologies (such as, household robots, eHealth devices) could help people with limited physical opportunities.[175] Another report shows that this could furthermore indirectly contribute to the sustainability of health systems by acting on the impacts of aging demographics, increase individual productivity levels, and mitigate health-care costs. The need for caregivers' assistance could be reduced, working lives could be extended, or patients could be kept at home independently rather than in costly health-care facilities.[176]

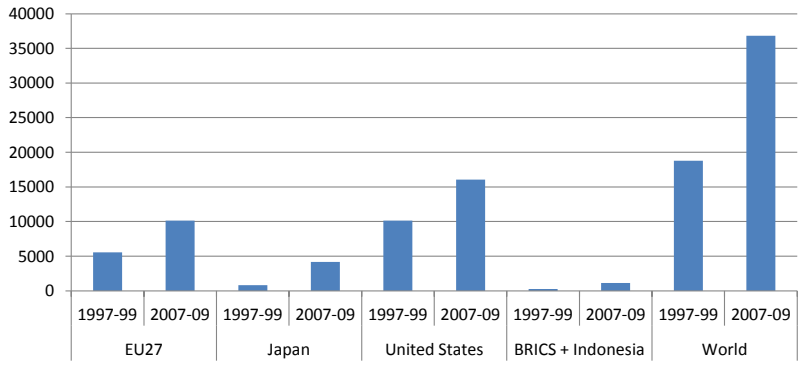


FIGURE 7. NUMBER OF PATENT APPLICATIONS FOR MEDICAL TECHNOLOGIES FILED AT THE WIPO UNDER THE PATENT COOPERATION TREATY, OVER THE YEARS 1997-1999 AND 2007-2009 PER REGION (OECD, 2011)

Figure 7 above shows the US leadership in total number of patents filed, this time followed by the EU-27, Japan, and the BRICS+.

Box 8: Examples of research projects in the medical device industry

Siemens is involved in joint research projects such as 'Smart Senior' aiming to develop technologies that help older people live more safely and easily in their own homes.[177] In addition, the company is working with partners to develop robots that can assist in providing health care to the elderly.[178]

Philips engages in wide-ranging R&D to develop new products that are applicable to older consumers, from specialized lighting options to a range of 'tele-health' or home-based care products that facilitate independence.[179]

INTEL has set up a center for Technology Research for Independent Living (TRIL) in Dublin, Ireland. It is dedicated to the definition and profiling of the aging process and to research in technologies that keep the elderly independent longer.[180]

Private not-for-profit

The private not-for-profit sector has also become increasingly active in funding health R&D research.[181] For five countries that invest most in health R&D (the UK, the US, Japan, Germany and France) 44.2% of not-for-profit R&D funding was allocated to cancer research in 2008, closely followed by CVDs (12.7%) and diabetes (9%). It shows a more limited focus on mental health disorders.[182] Research on NCDs is widely covered by charity funding (commonly supported by the general public or private foundations), while research on CDs remains mostly funded by private foundations themselves (generally supported by a single, non-public source of funding).

With respect to CDs, focus seems to be mostly on funding research initiatives on reproductive health in developing countries, poverty-related diseases through anti-HIV/AIDS and anti-malaria programs or vaccine initiatives, and neglected diseases.[183]

Box 9: Examples of private not-for-profit health research and actors

The Wellcome Trust is a British foundation, one of the largest research funders within the not-for-profit sector. With a budget of over £600 million in 2009, it is funding research in a wide range of topics: biomedical science (investigating health disease), technology transfer (from early-stage projects to medical applications), the support of research in low- and middle-income countries, medical history, ethics and society. Whereas the focus seemed to be on CVDs in the 1990s, more activities on infectious diseases such as malaria, diabetes, behaviors that influence health, eating disorders, and mostly neuroscience and mental health are increasingly explored.[184]

The Medicines for Malaria Venture is a Swiss foundation aiming to invest in R&D specifically for medicines combating malaria and bring them to the market. It combines a pharmaceutical expertise with a public benefit goal.[185]

CONCLUSION

Summing up the main conclusions from this section, we highlight several issues related to health research by countries, the EU and the private sector.

Investment by **governments** in health research are dominated by the US in both absolute and relative (to GDP) numbers. In Europe, Northern and Western European countries are the largest health R&D spenders. These countries also tend to have national R&D research strategies in place, which is less the case in Eastern Europe. Looking at research expenditure of five countries with the largest health R&D budgets shows that most funding flows to cancer research, followed by research on mental health issues and CVDs. Diabetes and chronic respiratory diseases receive much less funding. Large differences remain among countries, with France for example spending much resources on chronic respiratory diseases and Germany investing most funds in mental health research.

Research **at the EU level** mostly takes place within the successive Framework Programmes. Starting with FP7, health is designated as a separate research theme, receiving substantial amounts of funding of over

€6 billion. Unhealthy lifestyles and especially aging are increasingly singled out as central elements of health research. This is further reflected in the upcoming Framework Programme Horizon 2020, which lists 'health, demographic change and wellbeing' as one of six key challenges. Here again, the focus is predominantly on cancer research, followed by brain research and CVDs. Social and economic issues receive much less funding, only around 4.5% of the total health research budget. Other EU-funded projects do seem to focus more on research related to prevention and social inclusion.

Most health research is conducted by the **private sector**. In particular, pharmaceutical companies invest heavily in health R&D. Their research focuses predominantly on cancers, followed by respiratory disorders, mental issues and CVDs. Yet as emphasized in the previous chapter, it is likely that the bulk of future costs will be attributable to mental illnesses and CVDs. Obviously, the private sector hardly does research in areas such as sustainability of health-care systems, since these offer few commercial opportunities.[186] In terms of health R&D expenditure as a percentage of GDP, many European countries rank high. However, the US is leading in terms total pharmaceutical patents filed. The industry of medical devices is experienced to continue to growth, which is reflected in the increasing numbers of patent filings. This reflects growing research and innovation, which are mainly driven by the prospects of new markets and demand, due to aging in particular.

2.3 COUNTRIES OF EXCELLENCE

In the following sections, we identify a number of 'countries of excellence' in health research: countries that are particularly productive in publishing research on health challenges of prosperity. First we look at drivers (aging, unhealthy lifestyles and environmental issues), then diseases (the most pressing NCDs), and finally, we zoom in on social and economic health issues. The identification of R&D hotspots is based on bibliometric data (i.e. data on publications and citations). Data was retrieved from widely used databases, including Thomson Reuters' Web of Science, PubMed, the Science Citation Index, and the World Bank eLibrary. Though data was not available for all health challenges of prosperity, we were able to give an overview for most health issues likely to form a particular concern for Europe.

DRIVERS

As noted in the previous section, research related to drivers of health challenges of prosperity is mostly a public concern. Yet it also appears that most investments are focused on aging, and to a lesser extent on unhealthy lifestyles and environmental health issues. Here we look at which countries conduct research in these three areas. The bibliometric data is summarized in Table 7 on page 62.

Aging

Looking at publications in health research in the area of aging brings additional evidence that research output on aging is indeed considerable when compared to the other two 'drivers'.

As a research field, aging connects multidisciplinary studies in both epidemiology and public health, for example on the biomedical mechanisms behind the biological causes and effects of aging, as well as the wider implications for society. Table 7 on page 62 shows that the US tops the list with most publications.[187] The country produces more than six times the total publications of the UK. Other European countries ranking high are Italy, Germany and the Netherlands. For Germany and Italy, this is in parallel to the growing cohorts of elderly facing both countries (as shown in our online Monitor[188]). Interestingly, looking at the citation impact, the most cited research is carried out in the UK and most Northern European countries, including Scandinavia and the Netherlands.

Unhealthy lifestyles

As for unhealthy lifestyles, we looked at tobacco-, obesity- and alcohol-related research. Bibliometric data on physical inactivity research was unavailable, probably because it does not constitute a well delineated research area.

European journals focus relatively strongly on **smoking** research. A 2007 study analyzing data between 1999 and 2003 shows that US journals published the largest number of studies (31%), closely followed by the UK (29%). Further behind are Germany and the Netherlands (both about 9%).[189] Research output has doubled in Europe between 1999 and 2003. Another more recent study on tobacco-related research between 1980 and 2009 confirms this trend.[190] The report furthermore notes that research focus has

shifted over time. The effects of smoking on health remain the main research area, though its relative importance has declined. More attention has been paid to the behavior itself (why do people smoke?), individual risk factors and the prevalence of smoking. Furthermore, more research looks at ways to combat smoking through prevention, tobacco control, and cessation. This suggests an increasing focus on prevention and drivers.

Similarly, the number of publications on **obesity** between 1988 and 2007 has rapidly increased, particularly since the end of the 1990s.[191] This reflects the concerns raised over the rise of obesity rates. Perhaps unsurprisingly, the US emerges as the leader in obesity research in absolute terms, as shown in Table 7. With more than 40% of all publications, the US far outpaces other European countries. That said, the study from which we retrieved the data indicates that Western and Northern countries of Europe appear as the main producers relative to GDP and population, especially the UK, Italy, France and Germany. In particular, Nordic countries have the reputation of having developed a strong knowledge base and high scientific standards.

Looking at **alcohol**-related research, one study shows that between 1992 and 2003 the number of papers published in the developed world remained limited compared to the related economic and social costs.[192] Alcohol research represented only 0.7% of the total expenditure of biomedical research. Research is mainly conducted in Canada and the US, which account for about 58% of all papers published, against 30% in Western Europe. In Europe, research production of Finland, Sweden and Spain was greater than the worldwide average. A correlation between alcohol abuse and research in alcohol seems unlikely.

Environmental health issues

With regards to environmental health issues, data was only available for *public* environmental health research in European Economic Area countries plus Switzerland. Between 1995 and mid-2005, publications in these countries accounted for around one-fifth of the worldwide total.[193]According to this study, research on the links between health and the environment has increased over this period. This underlines the rising awareness of environmental health issues. When looking at individual countries, Table 7 below suggests a strong concentration of research efforts in Germany. Next

in line are Sweden and Italy, followed by France and the Netherlands. The relatively strong position of Sweden, Finland and Denmark is confirmed when looking at publications relative to GDP and population size.

Across all selected countries, research is mostly focused on topics such as work environment, environmental exposures and illnesses. Another interesting finding is that national incomes positively correlate with research on environmental issues. This corroborates our earlier statement that sensitivity towards environmental issues is greater in high(er)-income countries.

	AGING*		OBESITY**	ENVIRONMENTAL ISSUES***
COUNTRY	NUMBER OF ARTICLES PUBLISHED	CITATION IMPACT (CIT./ART.)	NUMBER OF ARTICLES PUBLISHED	NUMBER OF ARTICLES PUBLISHED
Australia	2.813	8,6	1.492	n/a
Austria	536	10	n/a	94
Belgium	695	11,7	558	199
Brazil	n/a	n/a	821	n/a
Canada	4.190	8,7	1.809	n/a
China	1.117	5,9	648	n/a
Czech Republic	n/a	n/a	n/a	95
Denmark	588	13,3	757	334
Finland	847	10,1	624	386
France	1.753	10,5	1.940	529
Germany	3.456	9	1.826	979
Greece	289	7,6	n/a	110
Ireland	496	10,1	n/a	n/a
Israel	1.095	7,4	433	n/a
Italy	3.593	10,5	2.520	781
Japan	2.856	6,6	2.609	n/a
Netherlands	2.318	11,3	960	452
Norway	385	12,4	n/a	256
Other EEA countries	n/a	n/a	n/a	207
Poland	391	6,3	721	305
South Korea	886	5,9	394	n/a
Spain	1.200	9,9	1.407	380
Sweden	1.849	10,6	1.395	793
Switzerland	1.003	9,7	733	151
Turkey	370	5,9	n/a	n/a
United Kingdom	7.253	24,9	3.205	303
United States	44.556	7,2	20.294	n/a

* Number of publications on aging between 1999 and 2010 in 'aging research journals', per country and citations per article ratio (Thomson Reuters' database Web of Science).

** Number of articles on obesity research published between 1988 and 2007 for the 10 best performing countries (PubMed, 2009).

*** Number of articles published on environmental health research from mid-1995 to mid-2005 (part of the SPHERE project, Strengthening Public Health Research in Europe, 2007).

TABLE 7. BIBLIOMETRIC DATA FOR EACH DRIVER, WITH THE TOP 3 COUNTRIES HIGHLIGHTED

DISEASES

This section looks at which diseases receive most research attention. As shown in the second chapter, investments on diseases appeared to be mainly focused on NCDs, mostly on cancers and to a lesser extent CVDs. Research on mental health issues was more limited for most countries. Here we look at a number of 'countries of excellence' in these three groups of diseases that (will) form the main concern for high-income countries. The bibliometric data is summarized in Table 8 on page 65.

Cancers

As noted earlier, cancer research (or oncology) is an area that attracts substantial attention from both public and private actors. Indeed, one study suggests that between 1999 and 2003, cancer research papers had accounted for 13% of all biomedical research.[194] Overall cancer research expenditures are mostly directed towards drug research. Breast, colorectal, lung and prostate cancers have the highest disease burden. These four cancers, combined with leukemia, dominate the majority of research output.[195] It is worth reiterating here that as shown in the second chapter, the pharmaceutical industry accounts for a large share of this spending. Interestingly, there seems to be little research on associations between cancer and social inequalities and stress.[196]

Table 8 shows that the US again tops the charts, with almost five times the total number of articles published by the UK, ranking second. That said, with almost more than 221.000 articles Europe publishes more on cancers than the US (with close to 155.000 articles).[197] Germany, Italy and France rank third to fifth. When looking at citation impact, Finland scores highest, followed by the US, Switzerland, Australia, the Netherlands, and Sweden. It is interesting to note that Ireland is one of the least productive in terms of research intensity and impact, even though the country is expected to experience one of the highest European increases of the percentage of population with colorectal cancer through 2030.[198]

Cardiovascular diseases

Heart and circulatory diseases are among the biggest killers in Europe. Due to the prevalence and impact of such conditions, research on the cardiovascular system is frequently addressed by biomedical research. In the category of human diseases, only oncology produces more research output.[199]

A recent study has shown that there has been a steep growth of publications in cerebrovascular and cardiovascular diseases over the last fifteen years.[200] This increase seems to be due to more research on conditions like strokes. Research produced in the EU on average was more cited than that produced by the US between 1994 and 2008 (44.4% of total citations for the EU, against 30.3% for the US). At country level, the UK and Northern European countries are here again the most efficient producers both with regards to impact and relative to their national income.

Mental health issues

Mental health issues are a mounting concern in the developed world. As mentioned before, aging is likely to lead to a higher prevalence of dementias, and unhealthy lifestyles may increase the number of people suffering from depressions. In terms of total economic burden, such illnesses are expected to weigh heavily on our wealth. Yet mental health issues seem less subjected to research. That said, as the in-depth country analysis showed at the start of this chapter, individual country differences are large. Whereas Germany spent more than 27% of its health R&D budget on mental illnesses, Japan allocates just 14.9%.

However, there does seem to be a trend towards more investment in such research. According to a yet-to-be-published study, mental health research is growing faster than biomedicine and science in general.[201] This is confirmed in another paper, which shows that research in this area has significantly increased from 1997 to 2008.[202] Throughout this decade, research in mental health issues almost doubled in many European countries. Although they remain far behind the US (96.816 articles), the UK, Germany, Italy score high in terms of total publications with, for instance 25.889 publications for the UK. Looking at research impact, the US, but also the UK, the Netherlands, Switzerland, Belgium, and Scandinavian countries rank highest. The amount of German publications seems small compared to the country's considerable expenditure on mental health R&D, suggesting that funding is mostly used for more applied research.

	CANCERS*		MENTAL HEALTH**	
COUNTRY	NUMBER OF ARTICLES PUBLISHED	CITATION IMPACT (CIT./ART.)	NUMBER OF ARTICLES PUBLISHED	AVERAGE RELATIVE IMPACT FACTOR
Australia	8.493	21,5	9.240	1,055
Austria	5.570	17,1	2.289	0,895
Belgium	7.439	20,8	2.870	1,045
Brazil	n/a	n/a	4.446	0,46
Canada	18.470	20,8	13.475	1,165
China	10.569	13,8	2.532	0,97
Czech Republic	2.496	9,3	n/a	n/a
Denmark	4.326	20,2	2.049	1,105
Finland	3.593	26,4	2.942	1,1
France	23.114	19	7.865	0,86
Germany	34.337	16,8	15.897	0,93
Greece	5.531	11,6	n/a	n/a
Ireland	2.677	12,8	n/a	n/a
Israel	4.411	17,8	3955	1,03
Italy	32.163	14,3	8.861	1,04
Japan	33.885	17,3	8.498	0,875
Netherlands	15.649	21,4	8.502	1,18
Norway	3.812	20,6	2.025	0,96
Poland	4.440	11,7	n/a	n/a
South Korea	7.286	12	n/a	n/a
Spain	11.145	16,2	5.313	0,815
Sweden	9.026	21,2	5.487	1,05
Switzerland	7.861	21,7	3.891	1,03
Turkey	4.601	5,5	n/a	n/a
United Kingdom	37.757	17,8	25.889	1,195
United States	154.677	22,4	96.816	1,295

* Number of publications on cancer research between 1998 and 2009 per country and citations per article ratio (Thomson Reuters' database Web of Science, 2012).

** Number of publications on mental health between 1997 and 2008 per country and citations per article ratio (Observatoire des Sciences et des Technologies in Canada, Web of Science and Medline databases, in Larivière, V., 2010).

TABLE 8. BIBLIOMETRIC DATA FOR EACH DISEASE, WITH THE TOP 3 COUNTRIES HIGHLIGHTED

SOCIAL AND ECONOMIC HEALTH ISSUES

Research on social and economic health issues remains one of the most challenging and underdeveloped R&D areas. Below we look at country research performance in the field of health economics and health inequality.

Health economics

Health economics appears to receive less attention than research fields previously considered in this chapter. It confirms the observation mentioned in the second chapter regarding the limited importance of such research at EU-level.

As shown in Table 9 on page 67, in Europe Ireland, Finland, Germany, Denmark, France and Southern European countries such as Spain, Italy and Greece perform weakly – below the European average citation rate (14.5 based on the table's scores). This strongly contrasts with the financial sustainability issues these countries are likely to face. Finland, Germany, France or Denmark, will respectively have the highest shares of health-care spending as a percentage of GDP in 2030, and countries such as Finland, Germany or Ireland will face significant health-care workforce shortages through 2030.[203]

The Netherlands—ranking first—and Sweden surpass the US with respect to citation impact. It is furthermore worth noting that Japan falls behind all selected countries: the country is one of the fastest aging countries in the world, which will likely have an impact on the cost of maintaining its health-care system.

COUNTRY	NUMBER OF ARTICLES PUBLISHED	CITATION IMPACT (CIT./ART.)
United States	10.995	24,6
United Kingdom	2.214	21,3
France	1.623	8,2
Canada	859	17,5
Australia	467	10,7
Netherlands	408	27,5
Germany	331	12,5
Spain	289	10,4
Sweden	260	24,7
Switzerland	226	15,7
Italy	155	8,4
Norway	133	18,6
New Zealand	128	12
Japan	113	5,6
China	113	7,6
South Africa	110	7,3
Belgium	109	9,9
Denmark	94	10,4
Finland	64	13,1
Israel	64	27,5
Ireland	63	14,7
India	63	9,7
Greece	54	6,4
Austria	28	16,2
Philippines	18	22,1

TABLE 9. HEALTH ECONOMICS: NUMBER OF PUBLICATIONS ON HEALTH ECONOMICS FROM 1969 TO 2010 PER COUNTRY AND CITATIONS PER ARTICLE RATIO (WORLD BANK, 2011)

Health inequalities

As shown in the first chapter of this report, national income and income inequalities have considerable health impacts. Health inequalities may even be exacerbated due to the economic crisis that has severely hit Europe. This area of research is mostly funded by public actors, and more attention has been paid to such issues within EU research programs in recent years. But though overall research effort appears to remain limited in comparison

to other areas, the mitigation of health inequalities can lead to better population health.[204]

In line with these observations, the WHO Commission on Social Determinants of Health has recommended to strengthen focus on the social determinants of health in public health research. Further, the WHO Commission notes that there is insufficient interdisciplinary research on health inequalities, and insists on the need for research on the connections between health equity, social factors and environmental issues, in particular climate change.[205]

A study by the University of Ottawa which analyzed publications on health inequalities research between 1966 and 2011, shows that the number of publications has increased exponentially after 1990.[206] Focus is increasingly on trying to explain disparities in morbidity and mortality by social determinants. The most represented disciplines for health inequalities research are medicine, public health, epidemiology, sociomedical research and sociology. Of 56 identified countries producing research on health inequalities, most publications originate from the US (50% of total research production). In Europe, research leaders are the UK (33%) and the Netherlands (4%). Interestingly, Germany seems to produce little research in this field (1%). And finally, a major difference between the US and the UK research focus is that the latter deals with inequalities driven by *social* classes, whereas US researchers emphasize more general differences and disparities such as race.

2.4 CONCLUSION

This second chapter provided an overview of funding and priorities by major R&D actors and countries of excellence in three main research areas: drivers, diseases and social and economic health issues. With regards to actors, the following main conclusions stand out:

Health research is primarily funded and conducted by **private sector research**; it contributes to over half of all funding. The importance of the private sector becomes even more evident when looking at research on diseases, where about two-thirds of research money comes from companies.

Pharmaceutical research focus is predominantly on cancers, followed by respiratory disorders, mental issues and CVDs. In some European countries, pharmaceutical companies spend more than in the US in terms of health R&D expenditure as a percentage of GDP, though the US is the unrivalled leader in terms of total number of pharmaceutical patents filed. It should be noted that in the **medical device industry**, patent filings are steadily growing at the global level.

When looking at **total governmental health research**, the US spends almost 0.35% of GDP on health R&D, followed by Northern and Western European countries. Austria and Sweden allocate around 0.25% of GDP to health R&D, Finland, the Netherland, Spain, France and Germany, Denmark and the UK, all spend around 0.15%. These countries also tend to have health R&D research strategies in place, which is less so in Eastern European countries.

An **in depth country analysis of health research funding** of Germany, the UK, France, the US and Japan, shows that over a quarter of funds are allocated to cancer research, followed by research on mental health issues and CVDs. Diabetes and chronic respiratory diseases receive much less funding. Individual differences between these countries are considerable.

EU research programs focus heavily on health, with more than €6 billion allocated to health as a research theme under FP7. This furthermore illustrates the international dimension of health research in Europe. The focus is predominantly on cancer research, followed by brain research and CVDs. Much less research funds flow to social and economic issues, with around 4.5% of the total health research expenditure looking at such issues. Other EU funded projects, though smaller in size, do seem to focus more on research in prevention and social inclusion.

EU funded health research is **increasingly interdisciplinary**, which is illustrated by the budget allocated to research on the sustainability of health-care systems and the new grand challenge approach of Horizon 2020, which should reserve €9 billion for research on health, demographic change and wellbeing.

The results on countries of excellence can be summarized in the table below.

		TOTAL PUBLICATIONS	YEARS	AVERAGE PUBLICATIONS PER YEAR	GEOGRAPHICAL COVERAGE	TOP 3 COUNTRIES (TOTAL PUBLICATIONS)	TOP 3 COUNTRIES (IMPACT)
DRIVERS	**Aging**	84.535	1999-2010	7.685	Worldwide	US, UK, Canada	UK, Denmark, Norway
	Unhealthy lifestyles						
	Smoking	n/a	n/a	n/a	Worldwide	US, UK, Germany	n/a
	Obesity	45.146	1998-2007	5.016	Worldwide	US, UK, Japan	US, UK, Japan
	Alcohol	n/a	1992-2003	n/a	Worldwide	Finland, US, Sweden*	
	Environmental issues	6.354	1995-2005	635	EEA	Germany, Sweden, Italy	n/a
DISEASES	**Cancers**	453.328	1998-2009	41.212	Worldwide	US, UK, Germany	Finland, US, Switzerland
	CVDs	n/a	1994-2008	n/a	EU, US	n/a	n/a
	Mental health	232.842	1997-2008	21.167	Worldwide	US, UK, Germany	US, UK, Netherlands
SOCIAL AND ECONOMIC HEALTH ISSUES	**Health economics**	18.981	1969-2010	463	Worldwide	US, UK, France	Netherlands, Israel, Sweden
	Health inequalities	n/a	1966-2010	n/a	Worldwide	US, and in Europe: UK, Netherlands	n/a

* Relative research commitment relatively to presence in global biomedical research

TABLE 10. SUMMARY OF DATA GATHERED ON PUBLICATIONS FOR THE THREE CATEGORIES OF RESEARCH AREAS AND SELECTED HEALTH CHALLENGES

Aging research is mostly produced within research organizations located in the UK, Italy and Germany. Denmark, Norway and the UK score best with regards to research impact.

Unhealthy lifestyles:

- There is a strong and increased focus on *tobacco-related research*, which is in line with the high impact of smoking on health, as noted in the first chapter. Most research is conducted in the US, the UK and Germany.
- Corresponding to the rise of the obesity, there has been a steep increase in *obesity-related research*: it has multiplied by a factor of 37 within a decade. This seems especially due to US research activity. The main countries of excellence producing such research are the US, Germany, Italy, France and Finland.
- *Alcohol-related research* receives less attention than the two abovementioned health risk factors. At the same time, alcohol amounts to a high share of DALYs in Europe. Nordic countries and Spain account for most research production.

Research intensity is significantly less for **environmental health issues**. The major countries of excellence are Germany, Sweden, Italy, Denmark and Finland. Countries with the highest national incomes seem to publish more in this field.

Diseases: Most resources published aim at disease treatment, rather than prevention focusing on health risks. When looking at the three most costly NCDs, the following observations were made:

- Regarding *cancer research*, the US is most productive in publishing papers. In Europe, the highest impact and efficiency of research production is observed among Scandinavian countries. Yet looking at the economic burden of this disease, cancer research seems somewhat overemphasized.
- According to our sources, the second most intensively researched area in human diseases after cancer research is research on *cardiovascular conditions*. In this field, a strong growth in research production has been observed in recent years. Yet it remains small in comparison to cancer research.
- *Mental health issues* are also relatively less subjected to research than cancers. However here too research production is rapidly growing.

The interest for **social and economic health issues** emerges as much more limited in terms of research production.

- For *health economics*, countries that should demonstrate growing concerns with respect to their public finances, do not necessarily invest most in this research category. That said, social and economic health issues de receive gradually more attention in EU research programs.
- Especially since the 1990s, health inequality research has rapidly increased. Though most research comes from the US, the UK and the Netherlands stand out as producing most research on health inequalities in Europe.

3 RESEARCH OPPORTUNITIES

This final chapter will highlight promising research initiatives that aim to tackle Europe's future healthcare challenges. It is partly based on the analysis articulated in the previous chapter, which showed to what extent current research efforts are already geared towards the challenges we identified at the start of this report. Furthermore, it takes into consideration recent foresight studies and input from experts from the Netherlands Organization for Applied Scientific Research (TNO).

From a 'grand societal challenge' perspective, research should focus on the health issues we identified in the first chapter. To reiterate, these issues include: drivers (aging, unhealthy lifestyles and environmental issues); diseases (in particular mental health issues, CVDs, and cancers); and, social and economic issues (health inequalities and the sustainability of health-care systems). In comparing the current research activities to the identified priorities and challenges, there seems to be a case for increased research focus on:

- Mental health issues and CVDs, areas which will likely represent the largest future economic burden for Europe;
- Health inequalities and the sustainability of health-care systems are promising areas, however, they currently receive little attention in research.

Box 10: Focus on major NCDs

In line with the challenges we identified in the first chapter, and with the current priorities of health R&D actors described in the second, most foresights point to research on major NCDs as important focus-areas for future technological research.

With regard to *cancer* research, the following innovations are identified: systems biology, i.e., methods based on interdisciplinarity for more effective treatment using quantitative methods (hypotheses and predictions); nuclear physics, as radioactivity can be used in medical diagnosis and treatment; receptors for targeted immunotherapy in patients (e.g. to help their immune system fight cancer); complex laser beams and ion beams for therapy targeting the tumor more efficiently; and cells that block the development of tumor cells.[207]

Technological research on *cardiovascular diseases* (which will remain the leading killers in Europe), principally research on heart diseases, is also widely mentioned within our selection of foresights. The physiological autonomic regulation of heart activity through the use of human enhancement technologies[208] (HET) was cited as an example of how advanced technologies are improving the capacities of patients.

Mental health is also highlighted as a promising future research area, focusing on treatments for dementia, Alzheimer's and depression. For dementia, research is increasingly geared towards the links between genetics and external components (such as physiological mechanisms), which both influence the aging process. Furthermore, environmental and lifestyle factors are being increasingly taken into account in research vis-a-vis their roles in the development of such diseases. Progress is also expected in the early diagnosis of neurodegenerative illnesses.[209]

In the following pages, we provide guidelines for how future research strategies can better address these and other health challenges. In the first section, we show how health research could benefit from a more encompassing paradigm, which would be both interdisciplinary and intersectoral in nature. The second section explores the way in which medical research is currently conducted, and advocates for a more personalized approach to research. The third section argues for more

comprehensive research on the economic effects of prevention. Finally, the importance of research on health inequalities is highlighted.

3.1 A NEW RESEARCH PARADIGM

A new paradigm in health research is needed in order to tackle the health challenges of prosperity. The first part shows why the current dominant health definition is outdated and how research efforts would benefit from a more dynamic conceptualization. In addition, the need for more interdisciplinary research is emphasized.

A MORE DYNAMIC HEALTH DEFINITION

The dominant definition of health is based on the 1948 WHO definition, which defines it as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity".[210] According to some authors, this definition is not merely conceptual in nature, but also influential in practice, as it shapes what research is actually conducted. This interpretative application explains current biases in research that may be circumvented by a new health definition.

Critics argue that the prevailing definition of health has led to a *medicalization of society and research*.[211] This phenomena, has resulted in the broadening of the definition of disease, and correspondingly, what measures are needed in order to cure or prevent diseases. Indeed, the abovementioned definition suggests that reaching complete wellbeing and having no disease would be the only way to be 'healthy'. As one author writes, such "requirement for complete health would leave most of us unhealthy most of the time".[212] Especially due to aging, more and more people will have some sort of disease. Instead of striving for disease-free lives, we must learn to cope with the higher prevalence of illnesses.[213] In addition, this definition of health is said to have indirectly led to the continuous expansion of health-care systems through, for example, more and quicker medical interventions.[214]

Furthermore, this definition is *static*. For this reason, it may fail to consider other elements of a healthy life that are more dynamic in nature, such as the ability of people to cope with future health issues. A quick cure for diseases is not necessarily better for your health than increasing resilience to cope with future diseases. Rather than simply administering treatments after symptoms have appeared, new perspectives that focus on building

stronger body resilience can help patients cope well with disease.[215] This latter element is at the core of a new health definition suggested by Huber and others. Their definition of health stresses the "ability to adapt and to self-manage" as key to what constitutes a healthy life.[216] Here health is defined as a more 'dynamic' state, that results from the interaction of people with their environment. The extent to which individuals are resilient and their ability to respond adaptively and independently determines their level of good health. Even a person with a disease may still be considered healthy as long as the person is able to adapt and live a normal life.

AN INTERDISCIPLINARY APPROACH

Health issues are often the result of various causes, varying from physical, mental or socioeconomic factors. Yet as pointed out in the second chapter, research frequently focuses on isolated health issues with little interdisciplinary research, limited collaboration among actors, and few common research priorities. A more encompassing, interdisciplinary health research paradigm could overcome the fragmented nature of health R&D. Such research is based on the collaboration of scientists from diverse disciplines, with the objective to tackle multifaceted health issues; reach a consensus on clinical definitions; and, improve the comprehensiveness of health-care services.[217] Concretely, this would involve a range of initiatives, such as clinical trials, health policy analysis, environmental health, and research on health services.[218] In addition, it may imply more cooperation between public and private actors (as shown in Box 11).

Box 11: Public-Private Partnerships (PPPs)

Another element of the paradigm could be increasing public and private research cooperation, in particular in the form of public-private partnerships (PPPs). PPPs have been increasingly set up to achieve joint research funding. This is part of a twofold movement.

On the one hand, pharmaceutical companies appear to be entering a phase of crisis due to, for instance, expiring patents as explained in the second chapter, and the rising costs of developing new drugs.[219] On the other hand, the public sector is struggling to maintain sustainable health-care systems. In the light of current economic crisis and cutbacks on government expenditures, public actors are looking into new

funding sources. At the same time, pharmaceutical industry and medical companies can benefit from shared funding – which is especially interesting for pharmaceutical companies that are dealing with the higher costs of developing new drugs and with the expirations of their patents.[220] In addition, the medical device industry, which is growing, may envision seizing new opportunities of collaboration with the public sector in order to enter the national loop of health-care provision and processes. Hence PPPs represent economic incentives for both public and private sector actors. This has led to an increase of PPPs over the years. Sharing resources and knowledge may lead to more efficient research and the development of new drugs. In turn, these could be made accessible to patients through public actors managing health-care systems, spurring revenues for private actors and improving the health of populations.[221]

Strategies of countries like Germany and the UK steer towards more intensive cooperation with the private sector in health research (see Box 5). And within Horizon 2020, the European Commission seeks to increase the number of PPPs, particularly in the area of cancer research.[222]

A recent report by Price Waterhouse Coopers notes that the number of PPPs are increasing in Europe.[223] One of the most sizeable deals was made in 2010 for €1.5 billion, with the objective of building the first teaching hospital in Sweden: New Karolinska Solna University Hospital. The project is a consortium that includes a Swedish construction company, an architect firm, and a British investment fund.[224] It integrates health, science and education within the scientific cluster of Stockholm Science City that includes laboratories and research centers. Another example is the national eHealth portal of Denmark which has been created by Danish authorities and a consortium of private partners such as IBM.[225]

According to the database of the Global Forum for Health Research, the majority of selected international PPPs (76 out of 91) are dedicated to the prevention and control of CDs such as HIV/AIDS, tuberculosis and malaria.[226] These PPPs can be managed by companies owned by the public sector but can also include private sector actors, civil society actors, NGOs, or not-for-profit sector organizations.

There is a consensus on the idea that R&D efforts would benefit from knowledge sharing across disciplines,[227] and from an efficient translation and implementation of this knowledge into health-care institutions.[228]Indeed, the complexity and rising prevalence of some diseases require medical research to explore beyond a single area, as well as a more rapid and extensive sharing of data. Other fields, such as research on health inequalities, would also benefit from more interaction between health-care professionals, fields of research, and the acors funding research.[229]

Box 12: Examples of interdisciplinary health research projects

At Cornell University in the US, the **Division of General Internal Medicine** has created multidisciplinary research and educational programs. Faculty experts operate in several areas, ranging from clinical epidemiology, health education, psychosocial science, health economics and research on health services; but also biostatistics and more ICT-oriented fields such as medical informatics, data analysis, computer programming, measurement theory, sampling, and program evaluation (including cost-benefit and cost-effectiveness analysis). The objective was to create new knowledge and a larger research agenda, in order to develop and perform clinical research, both on the effectiveness of health outcomes, but also on health disparities and behavioral science.[230]

The **Collaborative Research Awards Program in Alzheimer's Disease** has been set up in 2012 in the US. The program aims to supports interdisciplinary research on prevention, diagnosis, and cure of Alzheimer's disease.[231] Collaboration across disciplines could foster more creative approaches to advance research in this area.

Other major NCDs such as cancers are also subjected to increasingly interdisciplinary approaches in research, for example involving fields that are not traditionally connected to health research, such as physics, engineering and computer science. In October 2009, a campaign launched by the **US National Cancer Institute** sought to attract engineers and thinkers into cancer research, in order to understand the causes and the development of cancers, and producing new cancer treatments.[232]

One emerging research area that we briefly mentioned in the second chapter was 'systems medicine' and biology. Recently, several authors have suggested an even more encompassing 'systems thinking' approach to health research. Systems thinking can be best described as an attempt to view "an organization or system and its respective environment as a complex whole of interrelated and interdependent parts, rather than separate entities".[233] Such an approach promotes interaction between research stakeholders and individuals,[234] which can be defined as patient-centricity.

The purpose is to achieve interdisciplinary and transdisciplinary research, allowing scientists from different backgrounds to share methods, concepts, guidelines and integrate their disciplinary perspectives on health and health research.[235] A number of organizations already use this systems approach. For example, the Initiative on the Study and Implementation of Systems (ISIS) in the US studies tobacco dependence from both a biological and behavioral point of view.

It should be noted that emphasizing the importance of interdisciplinary health research does not mean abandoning specialized research altogether. Much of health R&D is so complex that it can only be pursued by experts devoting their time and resources exclusively to specialized research questions. It does, however, mean that in order for research strategies to tackle grand health challenges, an interdisciplinary health research approach needs to be implemented. The next section discusses a number of concepts related to the systems approach in health research.

3.2 PERSONALIZATION

The way most medicines are currently being developed is based on randomized clinical studies in which drug effects are compared with those of placebo groups or other drugs over large populations. But as a recent study points out, while prescribed treatments may reduce risks for a *whole group of patients* (the average individual), the desired effect of the medication does not necessarily apply to *each individual*.[236] Indeed, individual health histories vary widely depending on genetics, lifestyles, etc. Therefore, a more personalized research approach is suggested. Such an individualized and 'customized' method includes more interaction

between patients, practitioners and researchers, and is expected to result in a more effective development and administration of medicines.[237]

Some authors advocate that more emphasis should be placed on research evaluating the effectiveness of drugs during the treatment implemented on each individual.[238] Personalization can ensure this. For example, through the development of individualized medical care (i.e., genetically-based) genetic testing could be used to dissect and predict an individual's proneness to risks such as side-effects to certain treatments.[239] Promising tracks in drug development technology can also be observed in the evolution of stem-cell treatments,[240] particularly vis-a-vis their use in the 'personalized' treatment of neurodegenerative disorders, such as Alzheimer's disease.[241] Indeed, this illness is currently commonly treated with the same drugs for all patients, whereas there are multiple pathways in which such diseases may develop such as environmental factors and diets.[242]

Box 13: Examples of personalization in health and health care

Risk assessment processes are becoming more customized. In diabetes research, a Risk Score has been developed by the **Leibniz Association** in Germany. This tool calculates an individual's personal risk of developing diabetes at an early stage.[243]

Depression may originate from both personal histories and risk genes. Methods used to detect depression processes before the symptoms manifest, and identifying the types of genes involved in the different forms of depression, are being developed by researchers at the **Max Planck Institute of Psychiatry**. This may lead to treatments targeting the disease earlier and more effectively. [244]

UMC Utrecht and **Harvard University** are developing a tailor-made solution through a computer model, with which physicians could calculate how much patients benefit from a treatment.[245]

Patient empowerment and self-management are two concepts related to personalization. Both aim to afford individuals with independent lives, more responsibility, and control over their own health in both prevention and treatment processes. This could help in coping with new health challenges such as aging, for example by developing new tools for in-home care, thereby increasing the independence of elderly. This could also mitigate the potential negative psychosocial effects of isolation and immobility on the elderly. Further, data could be collected and controlled by patients themselves, which may increase the effectiveness of health-care supply and reduce costs.[246]

3.3 PREVENTION AND ECONOMIC ISSUES

Disease prevention and the promotion of healthy behaviors could yield a number of positive economic effects.[247] Some skeptics oppose this argument by suggesting that preventive measures may actually result in higher public health expenditure, because increasing longevity may actually lead to greater total health-care demands.[248] Healthy life gains through prevention may thus have negative or cost neutral effects on health care expenditure.[249]

Yet one particular economic benefit of health promotion and disease prevention lies in the effects on productivity. As shown in the first chapter of this report, the costs of rising, yet preventable, chronic diseases will likely lead to considerable losses in terms of productivity. This is expected to subsequently impact our economies by limiting economic growth and reducing living standards. Related productivity losses through disability, unplanned absences, and increased accidents cost as much as four times more than the cost of treatment.[250] Healthier people are more productive than ill ones. Some studies indicate that prevention may positively affect productivity levels and lower mortality and morbidity, thereby reducing demands or cost pressures on health-care systems. For instance, one Norwegian report estimates that savings of $188 million could be made by lowering the population blood pressure level by a reduction in salt intake.[251]

In addition, since most expenses occur in the last six months of our lives,[252] prevention may simply mean that individuals die from different causes, while costs remain the same.[253] And while some preventive measures may

be cost-negative, others may have a positive effect. For instance, a 2006 study published in the *American Journal of Public Health* shows that while smoking cessation policies may cost nearly an additional $16.000 over the individual's lifetime, other interventions are cost-efficient, most notably prevention policies on obesity, diabetes or hypertension.[254] More precisely, some types of prevention approach may be more cost-efficient than others. One study suggests that in the prevention of hypertension and CVDs, there are two types of interventions, namely: the traditional individual-based approach (identifying high-risk individuals and providing them with treatments); and the population-based approach, which focuses on the drivers of health risks leading to CVDs among the whole population (through, for instance, campaigns aiming to curb unhealthy diets, health education, food labeling, etc.). Reports indicate that the latter type of intervention is more cost-efficient in developed countries: CVDs mainly occur among a large number of individuals that are exposed to lower risks, rather than within a small group of high-risk individuals.[255] As a result, more research is needed to identify and subsequently develop such cost-saving preventive measures. As a result, the argument against prevention based on the perspective that it would not lead to cost reduction does not seem valid for a number of reasons. First, it may hold for certain diseases, and only when looking at the effects on health-care expenditure. Second, when including the wider economic effects, most notably productivity gains, the net result is likely to be positive.

Another solution to reduce costs would be to **stimulate independent living**, as it would require less formal and labor-intensive care. Such innovation could focus on technologies adapted to working environments or long-term care at home, and could reduce costs by extending working lives and decreasing demand for formal and labor-intensive care.[256] Means to access and exchange relevant patient information could also become a crucial element of personalized medicine aiming at more efficient administration of treatments.[257] This could help in facilitating the prevention and targeting of potential diseases. To ensure such data availability, future research could be conducted in ICT in allowing for the continuous, real-time communication of a patient's physiological data,[258] but also clinical decision support. This would support independent living for people with limited physical opportunities. Cooperation between governments and medical device companies is particularly important. In the latter sector, it is interesting to

note the recent shift towards investments aimed at increasing independence. These investments include personalized health-care equipment solutions, which both empower patients and facilitate greater information control, such as glucometers, and sensor-embedded consumer products (e.g., sleep manager devices).[259]

Thus, focusing on health promotion and disease prevention deserves more attention in future health research strategies. This is in line with in the findings of a number of foresights.[260] Still, there is a need for more research assessing the total economic effect of health promotion,[261] early interventions, and the cost-effectiveness of integrative health care for chronic conditions.[262] In addition, and in line with said the argument formulated in the previous section, here too research should be more interdisciplinary.[263] To increase the knowledge base, fundamental research should be directed towards all major drivers, such as diets, lifestyles, pollutants, and on how to improve lifestyle habits.[264]

Box 14: A case for more ethical research

Aging, the rise of chronic diseases and sustainability issues will likely have an impact in the debate on the sustainability of health-care systems. These developments will raise sensitive ethical issues, many of which will likely be related to end-of-life situations. Not surprisingly, euthanasia is pointed out by several foresights as a topic that would merit more research.[265] A particular discussion concerns extending the lives of terminally ill patients, since one of the main reasons for the rising costs of aging is the exponential growth of health-care costs towards the end of life.[266] For example, a 2009 study by the Dartmouth Institute for Health Policy revealed that keeping terminally ill patients in the last two years of their lives in a hospital appears to be more of a financial decision undertaken by physicians: the more patients they see, the higher the fees practitioners receive. 30% of hospitalizations were deemed "probably unnecessary" by the report, and "20 to 30% of medical expenses during last two months of patients' lives may have had no meaningful impact". [267]

Researching end-of-life options such as pain management, nursing home, new home-based models of palliative care, and the choice of

medical treatments in end-of-life situations could prove particularly relevant in overcoming such a lack of cost-efficiency. This underlines the importance of more interaction between practitioners and patients, which would also afford more importance to patients' living wills and wishes regarding medical treatments and prolonging life.

Finally, although innovation is one of the main drivers of rising health care expenditure, cost-focused innovation may also relieve pressure on government expenditures. Although the exact effects are difficult to identify, some research areas look particularly promising. They include in-home care, 'low-cost' drugs, and prevention measures. Generic medicine, self-medication (such as currently customary pregnancy home tests or drugs for urinary infections) are examples of drugs that would be cheaper to manufacture than those they replace.[268] Encouraging the research and development of such drugs could prove to be cost-reducing. As mentioned in the second chapter, it should be noted though that in some cases, e.g. when demand rises faster than costs are decreasing, even cost-reducing treatments may paradoxically lead to higher health-care spending.

Developing innovations, supporting preventative measures, and the self-management of health may render health care more affordable. This can be achieved through new, convenient business models in health-care delivery, which include technologies in their offers to patients. Examples include, facilitated user networks for chronic disease prevention and management. Weight Watchers is an online coaching program that includes support and advice on helpful habits and smart eating. The network dLife aims to facilitate the exchange of advice and information among diabetics and their families.[269] Such models are expected to move simple procedures from hospitals to homes. They could improve the affordability of health care, as they deliver care at lower costs and offer alternatives to hospital and physician practices. It is worth mentioning here the increasing access to mobile and web device applications. They create solutions that are transforming the health-care industry. Familiar technologies (tablets, smart phones) can help patients manage preventive care by aggregating data, sending medication reminders, healthy habit tips and medical bill reminders, tracking blood sugar, blood pressure, pain, counting calories, etc. For instance, the mobile phone app mySugr helps diabetics manage levels of blood sugar concentration.[270]

3.4 HEALTH INEQUALITIES

Apart from the more straightforward recommendation that existing knowledge should be better used to solve health inequalities, research could focus more on the *causes* leading to potential health inequalities. Concretely, this means developing research on wider social determinants of health.[271] This includes for instance studies on the impact of child maltreatment, access to contraception, or funding for affordable housing.[272] Box 15 provides a number of examples. Furthermore, research processes (such as creating new drugs) and objectives should also take into consideration the circumstances of less advantaged populations and the issues of affordability and accessibility they are confronted with.[273] Several authors in the research community suggest that there is a strong case for more research on the relations between income distribution and population heath.[274]

Box 15: Examples of research programs on social determinants of health

The **Institute of Medicine of the University of Chicago** focuses on the impacts of urban poverty, violence and other variables such as high-school dropout on health and wellbeing.[275]

In Europe, the **Institute of Psychology, Health and Society** of the University of Liverpool has created a research group on 'Social Determinants and Health Inequalities'. Research themes include the improvement of equitable access to preventive and curative health care.[276]

Health inequality research would also benefit from more concentration. As some authors have noted, research efforts are currently highly fragmented.[277] Broader intersectoral and international cooperation between research areas is deemed crucial.[278] For example, the relationships between various consequences of social exclusion (including poverty) and the manifestations of health inequalities could be further investigated through cross-country comparisons.[279]

A final field of focus for health inequality research is medical or health literacy. Research could look at how to provide wider access to health-care

services[280] and information on drivers of good health such as nutritional habits that can help mitigate health inequalities.[281] Such research could aim to give to a larger public access to more knowledge of the consequences of both their individual behaviors and their use of health-care systems, thereby promoting healthier lifestyle choices and a more responsible use of health-care services. For example, new educational tools can help patients make more informed choices of health-care products, services and options.[282]

3.5 CONCLUSION

This chapter forms the final part of our research and suggests a number of building blocks for future research strategies aimed at tackling grand health challenges for Europe. In general, governments and societies would benefit from gearing research towards diseases that are likely to become most costly. Currently, research efforts are focused mostly on cancers, with social and economic health issues receiving relatively little funding. Yet the latter would benefit from more concerted attention, and the same holds for mental illnesses and CVDs. Similarly, research strategies should focus more on economic and social health issues, which are currently somewhat neglected. In addition, the chapter highlighted four specific issues:

We noted that **a new health definition and research paradigm** is needed. Such a paradigm should be based on a new health definition that stresses adaptation, self-management, and places more emphasis on social and economic issues. Furthermore, it should multidisciplinary and intersectoral in nature.

Pharmaceutical research should be more **personalized**. Such an approach could improve the prevention or targeting of diseases and the adequacy of interventions.

Targeted **prevention and cost-reducing innovations** may help in improving the sustainability of health-care systems. Technological research that improves the independence of the elderly could be especially promising in this respect. Furthermore, wider economic benefits, particularly those related to productivity gains, should be included in future cost-benefit analyses of prevention.

Lastly, regarding **research in health inequalities**, we call for greater focus on, and increased knowledge of, the social determinants of health and for the improvement of health literacy.

APPENDIX 1 – GEORISQ MONITOR 'THE HEALTH OF NATIONS'

Even though the right to health is one of the fundamental rights of every human being, the current status of health remains severe in several regions across the globe.

The GeoRisQ Monitor 'The Health of Nations' draws a detailed picture of the status of health world-wide and allows to identify the countries in which the situation is most alarming. As health is a multi-dimensional concept, the state of health of a population can be assessed against a number of standards, for which no single best measure exists.

METHODOLOGY

The data collection was geared to the purpose of a GeoRisQ Monitor 'The Health of Nations', showing the current status of health across the globe. To reveal the current health situation across the globe, we collected data for the following indicators: *Infant Mortality, Adult Mortality Rate and Health-Adjusted Life Expectancy (HALE)*. Using normalized scores, we subsequently ranked the countries on the basis of how they score relative to one another; the results were then combined into an aggregated status of health indicator (Aggregate Score).

For the Aggregate Score, we selected data from WHO and the World Bank. *Infant Mortality Rate* (see Map 2 in this Appendix) is an indicator of the World Bank for 2010; it is defined as the number of deaths of children aged under one year of age that occurred in a given year, expressed per 1000 live births.[283] According to the WHO, neonatal deaths are "a good indicator of both maternal and newborn health and care".[284] The WHO provided data for the second indicator, *Adult Mortality Rate*, in 2009 (see Map 3 in this Appendix); it is measured and defined by the probability of dying between the ages of 15 and 60 years (per 1,000 population). We selected it due to the rapid increase of disease burden from NCDs among adults. Yet they

represent to the most economically productive age span. Therefore, this indicator allows for a comprehensive assessment of the mortality patterns of countries.[285] *Health-adjusted Life Expectancy (HALE)* (see Map 4 in this Appendix) is defined as the average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury; it was measured by WHO for all countries across the globe for the year 2002. The rationale behind the selection of this indicator is that it captures "both fatal and non-fatal health outcomes" (therefore both mortality and morbidity) measuring a population's health status.[286]

The Aggregate Score 'The Health of Nations' represents the aggregation of normalized values for Infant Mortality, Adult Mortality Rate and HALE across the globe (see Map 1 in the report and in this Appendix). With the selection of these three indicators, we aim to approach the holistic concept of health status being described as emotional or social well-being of a population, physical disability, pain or risk of premature death, and beyond, the level of priority, efforts and resources devoted to public health and to the access to basic health services. Further, we used the elements selected by various international organizations for guidance.[287] Table 1 below lists the different indicators of the Aggregate Score, and their definitions.

INDICATOR	DEFINITION	SOURCE AND DATE OF PUBLICATION	YEAR(S)
THE HEALTH OF NATIONS: AGGREGATE INDEX	Represents the aggregation of normalized values for infant mortality rate, adult mortality rate, and HALE across the globe.		
INFANT MORTALITY RATE	The number of infants dying before reaching one year of age, per 1.000 live births in a given year.[288]	World Bank, 2012[289]	2010
ADULT MORTALITY RATE	Probability of dying between 15 and 60 years per 1.000 population.	WHO[290]	2009
HEALTH-ADJUSTED LIFE EXPECTANCY (HALE) AT BIRTH	Average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury.[291]	WHO, 2004[292]	2002

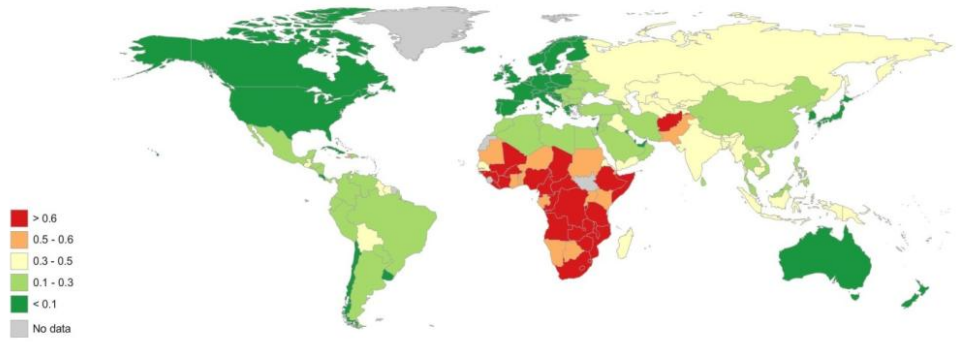
TABLE 1. INDICATORS OF THE GEORISQ MONITOR 'THE HEALTH OF NATIONS'

MAPS

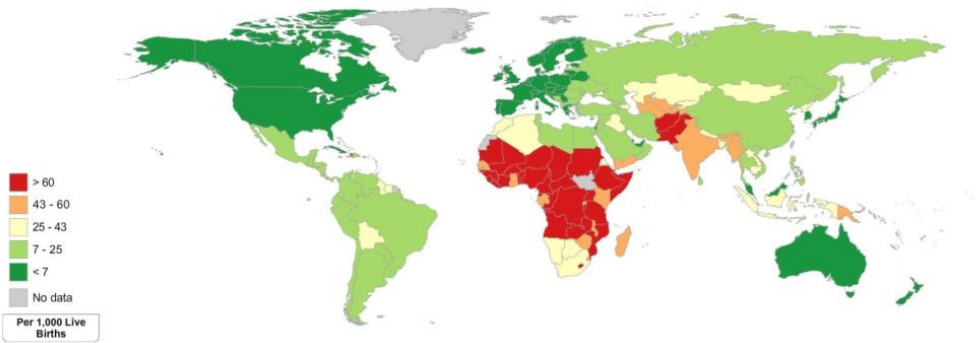
Unsurprisingly, this Monitor indicates that the status of health is particularly alarming across Sub-Saharan Africa and in South Asia, where multiple countries perform poorly across all three indicators. But, in addition, it exposes numerous other regions of interest.

Countries with an extremely poor status of health in Africa are (in descending order) Sierra-Leone, Somalia, Burkina Faso, Chad, Mozambique, Mali, Niger, the Central African Republic, the Democratic Republic of Congo, Guinea-Bissau, Côte d'Ivoire, Lesotho, and Benin. In South-Asia, we find especially the Afghan population in an alarming state of health. Other countries to be watched closely – although not among the worst performers – are Pakistan, Nepal, India, Cambodia, and Bolivia. A completely different picture can be drawn for the Western world.[293] In Northern America, Australia, New Zealand and the EU, the infant mortality rate is below 1% for most countries, nearly the whole population has access to improved sanitation facilities, and they are part of the only regions across the globe that surpass an average health-adjusted life expectancy of over 69 years. In the report, a closer look is taken at the EU, as it is one of the most positive examples for the current status of health and the focus of our study.

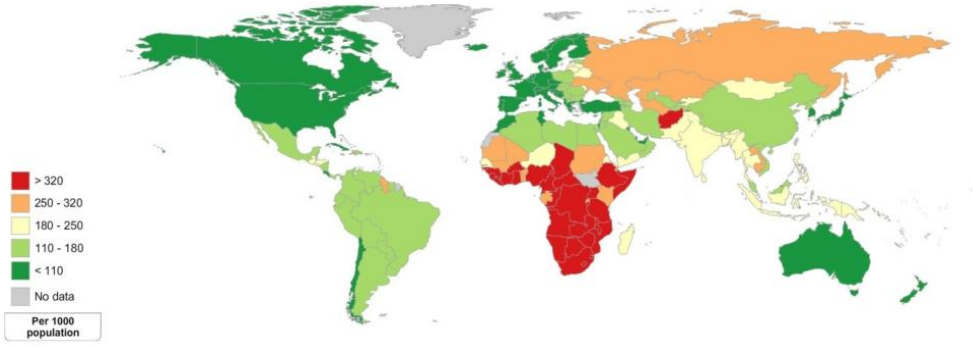
The following maps visualize the results for the Aggregate Score, and each of its three selected indicators.



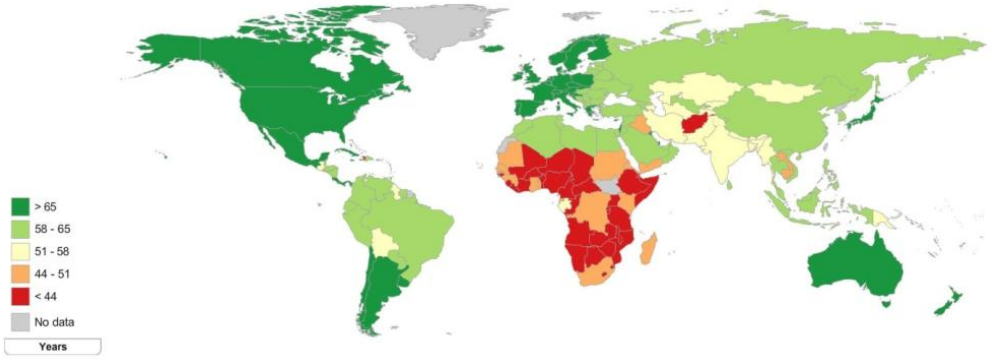
MAP 1. GEORISQ MONITOR FOR 'THE HEALTH OF NATIONS' – AGGREGATE SCORE INCLUDING INFANT MORTALITY, ADULT MORTALITY AND HEALTH-ADJUSTED LIFE EXPECTANCY



MAP 2. INFANT MORTALITY RATE IN 2010 (WORLD BANK, 2012)



MAP 3. ADULT MORTALITY RATE IN 2009 (WHO)



MAP 4. HEALTH-ADJUSTED LIFE EXPECTANCY (HALE) AT BIRTH IN 2002 (WHO, 2004)

APPENDIX 2 – GEORISQ MONITOR 'MALADIES OF PROSPERITY'

The GeoRisQ Monitor 'Maladies of Prosperity' reveals and assesses the major underlying drivers and behavioral risk factors that cause NCDs, namely Aging, Unhealthy Lifestyles, and Environmental Degradation.

METHODOLOGY

- Demographic changes lead towards ever-older populations which suffer from age-related diseases: in this monitor, we use *Aging* as a proxy for age related diseases. In the report, the results are visualized in Map 2.
- To measure Unhealthy Lifestyles, we used existing data sets on *Smoking*, *Physical Inactivity*, *Overweight*, and *Alcohol Consumption*. They are directly related to the rising prevalence of NCDs.[294] *Smoking* is one of the biggest health threats and an enormous driver for the rise of NCDs – especially cardiovascular diseases and respiratory system illnesses.[295]*Alcohol Consumption* is the European Union's third-largest risk factor for disease burden, and is associated with cardiovascular diseases, cirrhosis of the liver and various cancers.[296] Diseases associated with *Physical Inactivity* – the fourth leading risk factor for global mortality – are breast and colon cancers, diabetes and ischemic heart diseases.[297] *Overweight and Obesity* are ranked fifth on the list of leading causes of death. Common health consequences are cardiovascular diseases, including mainly heart diseases and strokes, and diabetes.[298] In the report, the results are visualized in Map 3. To measure the health impact of Environmental Degradation, we looked at outdoor air pollution and relied on data on *Particulate Matter (PM)*. Not only is this indicator used in many epidemiological studies and has been linked consistently with serious health effects;[299] it is also the most serious air pollution health risk in the EU,[300] and affects more people than any other frequently measured pollutant such as ozone, carbon monoxide, oxides of sulfur and nitrogen.[301] In the report, the results are visualized in Map 4.

CATEGORY OF INDICATOR	INDICATOR	DEFINITION	SOURCE	YEARS
UNHEALTHY LIFESTYLES	Unhealthy Lifestyles: Aggregate Score	Sum aggregate of normalized values for Smoking (38%), Physical Inactivity (28%), Overweight (22%), and Alcohol Consumption (12%).		
	Smoking	Current smoking of any tobacco product: prevalence estimates among adults aged 15 and over. 'Tobacco products' includes cigarettes, cigars, pipes or any other smoked tobacco products. 'Current smoking' includes both daily and non-daily or occasional smoking.	WHO[302]	2009
	Physical Inactivity	Percentage of defined population aged 15 and over attaining less than 5 times 30 minutes of moderate activity per week, or less than 3 times 20 minutes of vigorous activity per week, or equivalent.	WHO[303]	2008
	Overweight	Percentage of population aged 15 and over with a body mass index (BMI) of 25 kg/m2 or higher. A BMI superior to 25 means an individual is overweight, and a BMI superior to 30 corresponds to obesity. According to the WHO, the Body Mass Index (BMI) "is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults".	WHO[304]	2010
	Alcohol Consumption	Recorded amount of alcohol consumed among adults aged 15 and over, in liters of pure alcohol per person per year.	WHO[305]	2005
AGING	Population over 65	Percentage of population over 65 years old.	European Commission[306]	2010
ENVIRONMENTAL DEGRADATION	Outdoor Air Pollution	Annual particulate matter (PM10) in micrograms per cubic meter of air. "The major components of PM are sulfate, nitrates, ammonia, sodium chloride, carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air".	WHO	2008

TABLE 2. INDICATORS OF THE GEORISQ MONITOR 'MALADIES OF PROSPERITY'

APPENDIX 3 – GEORISQ MONITOR ON HEALTH-CARE EXPENDITURES

The three major drivers of maladies of prosperity – aging, unhealthy lifestyles, and environmental degradation – not only threaten the health of EU citizens, but also pose challenges for our economies and societies. In particular, they weigh on public health-care expenditure. The objective of this GeoRisQ Monitor is to illustrate the added financial pressure health-care spending may have on government budgets. The relative national increases in health-care expenditure as a percentage of a country's GDP between 2010 and 2030[307] form the single indicator of this Monitor and serve as a proxy of health-care systems' sustainability in Europe. Our calculations were based on the following rationale: we divided the percentage of GDP spent on health care in 2030 by that of 2010. The results reflect the increase in percentages. For example, as France is projected to spend 8.9% of its GDP on health care in 2030 and has spent 8.0% in 2010, the percentual increase of the country's health-care expenditure between 2010 and 2010 is 10.9%. The results are shown in Map 5 in the report.

ENDNOTES

1 OECD, *Health at a Glance: Europe 2010* (OECD Publishing, 2010), http://dx.doi.org/10.1787/health_glance-2010-en.

2 'Europe achieves historical milestone as Region is declared polio polio-free', June 21, 2002, http://www.who.int/mediacentre/news/releases/releaseeuro02/en/index.html.

3 Markus W.rz, Thomas Foubister, and Reinhard Busse, 'Access to Health Care in the EU Member states,' *EuroObserver, The Health Policy Bulletin of the European Observatory on Health Systems and Policies,* Vol. 8, no. 2 (Summer 2006): 1–8.

4 'Global Burden of Disease,' Health topics, *World Health Organization*, n.d., http://www.who.int/topics/global_burden_of_disease/en/.

5 *Projections of Mortality and Burden of Disease, 2004-2030* (World Health Organization, 2008), http://www.who.int/healthinfo/global_burden_disease/projections/en/index.html.

6 An overview of the methodology is provided in Appendix 1.

7 The World Bank, 'Mortality Rate, Infant (per 1,000 Live Births)', 2011, http://data.worldbank.org/indicator/SP.DYN.IMRT.IN; 'Health Statistics and Health Information Systems. Health Status Statistics: Mortality - Neonatal Mortality Rate (per 1000 Live Births),' *World Health Organization*, n.d., http://www.who.int/healthinfo/statistics/indneonatalmortality/en/.

8 'Adult Mortality Rate (probability of Dying Between 15 to 60 Years Per 1000 Population),' *World Health Organization*, n.d., http://apps.who.int/gho/indicatorregistry/App_Main/view_indicator.aspx?iid=64.

9 European Commission, *White Paper Together for Health: A Strategic Approach for the EU 2008-2013*, 9.

10 The National Bureau of Economic Health Research, 'The Happiness of Nations', http://www.nber.org/digest/jan06/w11416.html.

11 The figures are included for countries of the WHO European region, i.e., 51 nations: Western, Eastern and Central European countries but also Iceland, Israel, former Soviet Union republics, Russia, and Turkey. Data including such countries is therefore broader than Europe in its strict geographical sense.

12 International Agency for Research on Cancer, 'GLOBOCAN 2008', 2008, http://globocan.iarc.fr/.

13 World Health Organization, 'Projections of mortality and burden of disease, 2008-2030', http://www.who.int/healthinfo/global_burden_disease/projections/en/index.html.

14 Maria Siomos, *EU Research on Antimicrobial Resistance 2007-2010* (Brussels: Publications Office of the European Communities, 2011), 72, http://ec.europa.eu/research/health/infectious-diseases/antimicrobialdrug-resistance/pdf/eu-research-on-antimicrobial-resistance_en.pdf.

15 Jonathan Suk and J.C. Semenza, 'Future Infectious Disease Threats to Europe,' *American Journal of Public Health* 101, no. 11 (September 22, 2011): 2068–2079. European Foresight Monitoring Network, *Special Issue on Health care: Healthy Ageing and the Future of Public Health-care systems* (Brussels: European Commission, European Research Area, European Foresight Monitoring Network, November 2009), http://ec.europa.eu/research/social-sciences/pdf/efmn-special-issue-on-health care_en.pdf; *The European Environment | State and Outlook 2010. Assessment of Global Megatrends: Disease Burdens and the Risk of New Pandemics* (European Environment Agency, 2010), http://www.eea.europa.eu/soer/europe-and-theworld/ megatrends/disease-burdens-and-the-risk/view.

16 AVERT, 'European HIV and AIDS Statistics', n.d., http://www.avert.org/hiv-aids-europe.htm.

17 According to the WHO, it is a natural adaptation of microorganisms to products (e.g., antibiotics) that try tostop their growth.

18 Zsuzsanna Jakab, 'Towards a strategy on the containment of antibiotic resistance in the WHO European Region', World Health Organization, April 2011, http://www.euro.who.int/__data/assets/pdf_file/0006/137769/RD_Pres_strategy_antibio_resistance_2011.pdf.

19 J.E. Suk and J.C. Semenza, 'Framing Health Matters: Future Infectious Disease Threats to Europe,' *American Journal of Public Health* 101, no. 11 (November 2011),http://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.2011.300181.

20 Aging is a grand challenge in itself, with impacts beyond the realm of health. Therefore we wrote a seperate report on the Grand Challenge of Aging, available at www.hcss.nl/reports/.

21 *The 2012 Aging Report: Economic and Budgetary Projections for the EU-27 Member states (2010-2060)* (European Commission, Economic and Financial Affairs, 2012),http://ec.europa.eu/economy_finance/publications/european_economy/2012/pdf/ee-2012-2_en.pdf.

22 European Commission, 'Population Projections - Statistics Explained,' *European Commission - Eurostat*, April 2011, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Population_projections.

23 See our online GeoRisQ Monitor on aging *'Shades of Graying'* for more detail. It will be published in January 2013 on our website: http://projects.hcss.nl/monitor/.

24 European Foresight Monitoring Network, *Special Issue on Healthcare: Healthy Ageing and the Future of Public Healthcare Systems* (Brussels: European Commission, European Research Area, European Foresight Monitoring Network, November 2009), http://ec.europa.eu/research/social-sciences/pdf/efmn-special-issueon-healthcare_en.pdf.

25 Interested readers are referred to our online GeoRisQ Monitor *Maladies of Prosperity*, which includes a detailed report on the methodology, and analysis and an interface with several maps. See http://projects.hcss.nl/monitor/ and http://projects.hcss.nl/monitor/55/.

26 European Commission, *Establishing a Health for Growth Programme, the Third Multi-annual Programme of EU Action in the Field of Health for the Period 2014-2020*, 6.

27 Colin Mathers and World Health Organization, *WHO global report mortality attributable to tobacco* (Geneva, Switzerland: World Health Organization, 2012), http://whqlibdoc.who.int/publications/2012/9789241564434_eng.pdf.

28 World Health Organization, 'Tobacco', http://www.who.int/trade/glossary/story089/en/index.html.

29 European Commission, 'Directorate General for Health & Consumers - Health and Consumer Voice,' *Health and Consumers*, 2012, http://ec.europa.eu/dgs/health_consumer/dyna/consumervoice/create_cv.cfm?cv_id=551.

30 World Health Organization - Regional Office for Europe, 'Tobacco - Facts and Figures,' *WHO/Europe*, 2012, http://www.euro.who.int/en/what-we-do/health-topics/disease-prevention/tobacco/facts-and-figures.

31 World Health Organization, on behalf of the European Observatory on Health Systems and Policies, *Health in the European Union: Trends and Analysis, 2009, ec.europa.eu/social/BlobServlet ?docId=4742&langId=en.*

32 World Health Organization, 'Physical Activity,' *Global Strategy on Diet, Physical Activity and Health*, 2012, http://www.who.int/dietphysicalactivity/pa/en/index.html.

33 WHO Europe, 'Physical activity, Facts & Figures: 10 key facts on physical activity in the WHO European Region', http://www.euro.who.int/en/what-we-do/health-topics/disease-prevention/physical-activity/factsand- figures/10-key-facts-on-physical-activity-in-the-who-european-region.

34 WHO Europe, *Steps to Health. A European Framework to Promote Physical Activity for Health* (Copenhagen, 2007), http://www.euro.who.int/__data/assets/pdf_file/0020/101684/E90191.pdf.

35 According to the WHO, the Body Mass Index (BMI) 'is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults'. According to the BMI International Classification of adult underweight, overweight and obesity, a BMI superior to 25 means an individual is overweight, and a BMI superior to 30 corresponds to obesity.

36 WHO Media centre, 'Obesity and Overweight - Fact Sheet N°311,' *World Health Organization*, May 2012, http://www.who.int/mediacentre/factsheets/fs311/en/.

37 WHO Europe, 'Obesity', http://www.euro.who.int/en/what-we-do/health-topics/noncommunicablediseases/obesity.

38 World Health Organization, 'Obesity and Overweight', Fact Sheet N°311, May 2012, http://www.who.int/mediacentre/factsheets/fs311/en/.

39 World Health Organization, 'Alcohol', Fact Sheet, February 2011, http://www.who.int/mediacentre/factsheets/fs349/en/index.html.

40 OECD, *Health at a Glance: Europe 2010* (OECD Publishing, 2010), http://dx.doi.org/10.1787/health_glance-2010-en.

41 P Anderson and B Baumberg, *Alcohol in Europe: A Public Health Perspective* (London: Institute of Alcohol Studies, 2006).

42 Ibid.

43 WHO Media centre, 'Alcohol' - Fact Sheet,' *World Health Organization*, February 2011, http://www.who.int/mediacentre/factsheets/fs349/en/index.html.

44 Anderson and Baumberg, *Alcohol in Europe: A Public Health Perspective*.

45 World Health Organization, *Global Health Risks*, 'Part 2: Results', see Table 2, p. 12, http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_part2.pdf.

46 Interested readers are referred to our online GeoRisQ Monitor *Maladies of Prosperity*, which includes a detailed report on the methodology, and analysis and an interface with several maps. See http://projects.hcss.nl/monitor/ and http://projects.hcss.nl/monitor/55/.

47 As for aging, climate change is a much wider global and European concern. We wrote a full Grand Challenge report on Climate Change, which is available at www.hcss.nl/reports.

48 European Commission, *Establishing a Health for Growth Programme, the Third Multi-annual Programme of EU Action in the Field of Health for the Period 2014-2020*, 13. OECD, 'Health and the Environment', Policy Brief, February 2008, http://www.oecd.org/els/healthpoliciesanddata/40396531.pdf.

49 Ulla Lehmijoki and Elena Rovenskaya, 'Air Pollution Deaths in Europe 2020: A Survey', *Journal of Economic Literature*, Vol. 640, April 8, 2009, http://ethesis.helsinki.fi/julkaisut/val/kansa/disc/640/airpollu.pdf

50 *Health and the Environment*, Policy Brief (OECD, February 2008), http://www.oecd.org/health/healthpoliciesanddata/40396531.pdf.

51 Kirk R. Smith, *Environmental health – for the rich or for all?*, World Health Organization, 2000, http://www.who.int/bulletin/archives/78%289%291156.pdf.

52 European Commission, *Establishing a Health for Growth Programme, the Third Multi-annual Programme of EU Action in the Field of Health for the Period 2014-2020*, 13; 'Projections of the Effects of Climate Change on Allergic Asthma: The Contribution of Aerobiology,' *Allergy* 65 (2010): 1073–1081 ; IPCC, 'Has There Been a Change in Extreme Events Like Heat Waves, Droughts, Floods and Hurricanes?,' IPCC Fourth Assessment Report: Climate Change 2007, *Intergovernmental Panel on Climate Change (IPCC)*, n.d., http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-3-3.html.

53 Poumad.re et al., 'The 2003 Heat Wave in France: Dangerous Climate Change Here and Now,' *Risk Analysis* 25, no. 6 (2005): 1483–1494. 'A countrywide comprehensive epidemiological study was performed by the French National Institute for Health and Medical Research (.).The excess mortality was assessed (.). Persons over 75 years of age constitute[d] 82.49% of the Fatalities [in August 2003]'.

54 Nadia Kamel and Brian Ward, *Climate Change and Respiratory Disease. What the European Respiratory Society, ERS, Says Needs to Happen in an Era of Climate Change* (European Respiratory Society, 2009), http://dev.ersnet.org/uploads/Document/cc/WEB_CHEMIN_5568_1260432234.pdf; B. Forsberg et al., 'Impact of Climate Change on Ozone Induced Mortality in Europe' (Oral PresentationÐ: Outdoor air pollution studies presented at the European Respiratory Society's (ERS) Annual Congress, Amsterdam, September 27, 2011), https://www.ersnetsecure.org/public/prg_congres.abstract?ww_i_presentation=53289.

55 *Biodiversity and Health*, Future Brief (European Commission, DG Environment News Alert Service, October 2011), 4, http://ec.europa.eu/environment/integration/research/newsalert/pdf/FB2.pdf.

56 European Geosciences Union (EGU), 'Press Release: Cut emissions further or face risks of high air pollution, study shows', August 1, 2012, http://www.egu.eu/news/36/. See G. D'Amato and L. Cecchi, 'Effects of Climate Change on Environmental Factors in Respiratory Allergic Diseases,' *Clinical & Experimental Allergy* 38, no. 8 (August 2008): 1264–1274; J. G. Ayres and on behalf of the Environment and Health Committee of the European Respiratory Society, 'Climate Change and Respiratory Disease: European Respiratory Society Position Statement,' *European Respiratory Journal* 34, no. 2 (February 27, 2009): 295–302; 'Lung Doctors Expect Respiratory Diseases Will Worsen with Global Climate Change,' *UC Davis School of Medicine*, March 14, 2012, http://www.ucdmc.ucdavis.edu/publish/news/medschool/6320.

57 European Commission, *White Paper - Together for Health: A Strategic Approach for the EU 2008-2013* (Brussels: European Union, October 23, 2007), 3, http://ec.europa.eu/health-eu/doc/whitepaper_en.pdf; European Medicines Agency, *Road Map to 2015 - The European Medicines Agency's Contribution to Science, Medicines and Health* (London: European Union, 2011), 9, http://www.ema.europa.eu/docs/en_GB/document_library/Report/2011/01/WC500101373.pdf; World Health Organization, 'Chronic Respiratory Diseases,' *World Health Organization*, 2011, http://www.who.int/respiratory/asthma/scope/en/index.html.

58 *UN Agencies Call for the Adoption of a Sustainable Development Paradigm in the pan-European Region* (United Nations, Economic Commission for Europe (UNECE), March 26, 2010), http://www.unece.org/fileadmin/DAM/highlights/unece_weekly/weekly_2012/Weekly_470.pdf; Philippe Rekacewicz, 'Environmental Disaster in Eastern Europe,' *Le Monde Diplomatique*, July 2000, http://mondediplo.com/2000/07/19envidisaster.

59 'Eastern European Home Laundry: Sluggish Sales Mask Buoyant Production Growth,' *EuroMonitor*, July 6, 2012, http://blog.euromonitor.com/2012/07/eastern-european-home-laundry-sluggish-sales-mask-buoyantproduction-growth.html.

60 WHO Europe, 'Air Pollution and Health.'

61 WHO Europe, 'How can health systems respond to population ageing?', Policy Brief, http://www.euro.who.int/__data/assets/pdf_file/0004/64966/E92560.pdf, pp. 4-7.

62 See for example *The 2012 Aging Report: Economic and Budgetary Projections for the EU-27 Member states (2010-2060)* (European Commission, Economic and Financial Affairs, 2012), pp. 161-162, http://ec.europa.eu/economy_finance/publications/european_economy/2012/pdf/ee-2012-2_en.pdf.

63 Curative care aims to 'relieve symptoms of illness or injury'. Long-term care includes 'ongoing health and nursing care' for patients with chronic diseases and who need assistance on a daily basis du to increased disabilities and a reduced level of independence. For a latter, there is a notion of daily support through the use of additional health-care personnel. Source: OECD Health Data 2012, *Definitions, Sources and Methods: Health Expenditure and Financing.*

64 Wimo, Gustavsson, and Jönsson, 'Cost of Illness and Burden of Dementia in Europe - Prognosis to 2030.'

65 Wellness Councils of America, *The Costs of Unhealthy Behaviors*, 2007, http://www.welcoa.org/freeresources/pdf/costs_of_unhealthy_behaviors.pdf.

66 The United Health Foundation, the American Public Health Association and Partnership for Prevention, *The Future Costs of Obesity: National and State Estimates of the Impact of Obesity on Direct Health Care Expenses*, November 2009, http://www.fightchronicdisease.org/sites/fightchronicdisease.org/files/docs/CostofObesityReport-FINAL.pdf.

67 European Commission, Directorate General for Health and Consumers, *A study on liability and the health costs of smoking*, December 2009, http://ec.europa.eu/health/tobacco/docs/tobacco_liability_en.pdf.

68 The Economist Intelligence Unit, *The Future of Healthcare in Europe*, 2011, http://www.janssenemea. com/sites/default/files/The%20Future%20Of%20Healthcare%20in%20Europe.pdf, p. 9.

69 Ibid., p. 42.

70 European Commission, *White Paper - Together for Health: A Strategic Approach for the EU 2008-2013*, 9.

71 European Foresight Monitoring Network, *Special Issue on Health care: Healthy Aging and the Future of Public Health-care systems* (Brussels: European Commission, European Research Area, European Foresight Monitoring Network, November 2009), 15, http://ec.europa.eu/research/social-sciences/pdf/efmn-special-issue-on-health care_en.pdf; The Economist Intelligence Unit, *Future-proofing Western Europe's Health care A Study of Five Countries* (Economist Intelligence Unit, 2011), p.4, http://www.reforminghealth care.eu/uploads/Modules/Mediaroom/eiu-eucomed-future-proofing-health care-finalv2-web-5-10-11.pdf.

72 The Economist Intelligence Unit, *Future-proofing Western Europe's Health care A Study of Five Countries* (Economist Intelligence Unit, 2011), p.4, http://www.reforminghealthcare.eu/uploads/Modules/Mediaroom/eiu-eucomed-future-proofing-health care-finalv2-web-5-10-11.pdf.

73 *Technological Change and the Growth of Health Care Spending* (The Congress of the United States, Congressional Budget Office, January 2008), http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/89xx/doc8947/01-31-techhealth.pdf.

74 The Baumol Effect (or Baumol's cost disease) is an economic phenomenon conceptualized in the 1960s by William J. Baumol and William G. Bowen. See William D. Nordhaus, *Baumol's Diseases: A Macroeconomic Perspective*, Working Paper 12218 (National Bureau of Economic Research, May 2006), http://www.nber.org/papers/w12218.pdf.

75 R. Van Elk, E. Mot, and P.H. Franses, *Modeling Health Care Expenditures – Overview of the Literature and Evidence from a Panel Time Series Model*, Discussion Paper N°121 (The Hague: CPB: CPB Netherlands Bureau for Economic Policy Analysis, 2009), http://www.cpb.nl/en/publication/modelling-health-care-expendituresoverview-literature-and-evidence-panel-time-series-mo.

76 International Monetary Fund, *Fiscal Monitor: Shifting Gears. Tackling Challenges on the Road to Fiscal Adjustment, World Economic and Financial Surveys*, April 2011, p. 26, http://www.imf.org/external/pubs/ft/fm/2011/01/pdf/fm1101.pdf.

77 *The 2012 Aging Report: Economic and Budgetary Projections for the EU-27 Member states (2010-2060)* (European Commission, Economic and Financial Affairs, 2012), http://ec.europa.eu/economy_finance/publications/european_economy/2012/pdf/ee-2012-2_en.pdf. The AWG reference scenario takes into account the combined impact of aging, potential improvements in health status, and the effect of changes in the national income.

78 World Health Organization, *The determinants of health expenditure*, December 2011, http://www.resultsfordevelopment.org/sites/resultsfordevelopment.org/files/Transitions%20in%20Health%20Financing%20-%20The%20Determinants%20of%20Health%20Expenditure.pdf.

79 International Monetary Fund, *Fiscal Monitor: Shifting Gears. Tackling Challenges on the Road to Fiscal Adjustment, World Economic and Financial Surveys*, April 2011, p. 1, http://www.imf.org/external/pubs/ft/fm/2011/01/pdf/fm1101.pdf.

80 European Commission. Directorate-General for Economic and Financial Affairs, *The 2012 Ageing Report: Economic and Budgetary Projections for the 27 EU Member states (2010-2060) - European Commission*, 2012, http://ec.europa.eu/economy_finance/publications/european_economy/2012/2012-ageing-report_en.htm.

81 European Commission. Directorate-General for Economic and Financial Affairs, *The 2012 Ageing Report: Economic and Budgetary Projections for the 27 EU Member states (2010-2060) - European Commission*, 2012, http://ec.europa.eu/economy_finance/publications/european_economy/2012/2012-ageing-report_en.htm.

82 Busse, World Health Organization, and European Observatory on Health Systems and Policies, *Tackling chronic disease in Europe strategies, interventions and challenges*, p.1.

83 *Global Risks 2010*, A Global Risk Network Report (World Economic Forum, January 2010), http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2010.pdf.

84 Ibid., p.25.

85 World Economic Forum and Harvard School of Public Health, *The Global Economic Burden of Noncommunicable Diseases*, September 2011, http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011. pdf.

86 The World Economic Forum, *Global Risks 2010. A Global Risk Network Report*, January 2010, p. 24, http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2010.pdf.

87 *Global Burden of Disease 2004 - Part 4: Burden of Disease: DALYs* (World Health Organization, 2004), Fig. 21, http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_part4.pdf.

88 See our online GeoRisQ Monitor on aging *'Shades of Graying'* for more detail. It will be published in January 2013 on our website: http://projects.hcss.nl/monitor/.

89 Andrzej Rys, 'Who Will Care for an Ageing Population?,' *Health-EU Newsletter*, September 2010, http://ec.europa.eu/health-eu/newsletter/54/newsletter_en.htm.

90 Johan P. Mackenbach, *Health Inequalities: Europe in Profile* (Rotterdam: University Medical Center Rotterdam, 2006), http://ec.europa.eu/health/ph_determinants/socio_economics/documents/ev_060302_rd06_en.pdf.

91 Naoki Kondo et al., 'Income Inequality, Mortality, and Self Rated Health: Meta-analysis of Multilevel Studies,' *British Medical Journal* (2009): 1–9.

92 Mackenbach, *Health Inequalities: Europe in Profile*.

93 Johan P. Mackenbach et al., *Economic implications of socio-economic inequalities in health in the European Union* ([Brussels, Belgium]: European Commission, 2007).

94 OECD, 'Unmet Health Care Needs,' in *Health at a Glance 2011: OECD Indicators* (OECD Publishing, 2011), 130–131, http://dx.doi.org/10.1787/health_glance-2011-52-en.

95 Mackenbach et al., *Economic implications of socio-economic inequalities in health in the European Union*.

96 Karen Rowlingson, 'Does income inequality cause health and social problems?', Joseph Rowntree Foundation, September 2011, http://www.jrf.org.uk/sites/files/jrf/inequality-income-social-problemssummary. pdf. Kondo, N., Sembajwe, G., Kawachi, I., van Dam, R., Subramanian, S., and Yamagata, Z., 'Income inequality, mortality, and self rated health: meta-analysis of multilevel studies', *British Medical Journal*, N° 339, November 2009, http://www.bmj.com/highwire/filestream/398332/field_highwire_article_pdf/0/bmj.b4471. S. V. Subramanian and Ichiro Kawachi, 'Income Inequality and Health: What Have We Learned So Far?', Epidemiologic Reviews, Vol. 26, N°1, 2004, pp. 78-91, http://epirev.oxfordjournals.org/content/26/1/78.full. Kate E Pickett and Richard G Wilkinson, 'Child wellbeing and income inequality in rich societies: ecological cross sectional study', *British Medical Journal*, Vol. 335, N°1080, 2007, http://www.bmj.com/content/335/7629/1080.

97 OECD, *An Overview of Growing Inequalities in OECD Countries: Main Findings*, 2011, http://www.oecd.org/berlin/49171568.pdf . See also: Inequality Watch, 'The rise of income inequality amongst rich countries', February 2012, http://inequalitywatch.eu/spip.php?article58.

98 Kate E Pickett and Richard G Wilkinson, 'Child wellbeing and income inequality in rich societies: ecological cross sectional study', *British Medical Journal*, Vol. 335, N°1080, 2007, http://www.bmj.com/content/335/7629/1080; Karen Rowlingson, 'Does income inequality cause health and social problems?', Joseph Rowntree Foundation, September 2011, http://www.jrf.org.uk/sites/files/jrf/inequality-income-social-problems-summary.pdf.

99 Karen Rowlingson, 'Does income inequality cause health and social problems?', Joseph Rowntree Foundation, September 2011, http://www.jrf.org.uk/sites/files/jrf/inequality-income-social-problemssummary.pdf.

100 Lasse Tarkiainen, Pekka Martikainen, Mikko Laaksonen, Tapani Valkonen, 'Trends in life expectancy by income from 1988 to 2007: decomposition by age and cause of death', The Journal of Epidemiology and Community Health, 2012, N°66, pp. 573-578.

101 Ibid.

102 WHO Regional Office for Europe, 'Health Atlas,' *WHO Europe*, n.d., http://data.euro.who.int/equity/IA/AllIndicators/doubleMap/atlas.html; WHO Regional Office for Europe, *Poverty, Social Exclusion and Health Systems in the WHO European Region* (Copenhagen: World Health Organization, 2010), http://www.euro.who.int/__data/assets/pdf_file/0004/127525/e94499.pdf.

103 The opposite may also be true: health situation may affect someone's social and economic conditions, though it is believed that poor health leading to a lower socioeconomic status is less important than a lower socioeconomic status leading to poor health. Ibid.

104 Eurostat, *Combating Poverty and Social Exclusion. A Statistical Portrait of the European Union 2010*; WHO Regional Office for Europe, *Poverty, Social Exclusion and Health Systems in the WHO European Region*.

105 OECD Observer N°273, 'Bill of Health', June 2009, http://www.oecdobserver.org/news/fullstory.php/aid/2929/Bill_of_health.html

106 *Global Risks 2011* (World Economic Forum, January 2011), http://reports.weforum.org/wpcontent/blogs.dir/1/mp/uploads/pages/files/global-risks-2011.pdf.

107 World Health Organization, *Responsible life sciences research for global health security: A guidance document*, 'Definitions', pp. vii-viii, 2010, http://whqlibdoc.who.int/hq/2010/WHO_HSE_GAR_BDP_2010.2_eng.pdf. For other comparable classifications of health research, see the following two sources: Mark McCarthy et al., 'Comparing Public-health Research Priorities in Europe,' *Health Research Policy and Systems* 7, no. 1 (2009): 17. Strengthening Engagement in Public Health Research, *STEPS Report: Public Health Research – Europe's Future* (Strengthening Engagement in Public Health Research, 2011), http://www.steps-ph.eu/wpcontent/uploads/STEPS_Report.pdf.

108 Strengthening Engagement in Public Health Research, *STEPS Report: Public Health Research – Europe's Future*. pp. 14-16: Countries that include public health research in their national research strategy or mention it in their public health policies are (by alphabetical order) the Czech Republic, Denmark, Ireland, Latvia, Netherlands, Poland, Slovakia, Spain, Sweden and the United Kingdom. The 5 countries that include public health research as a priority in their national health

strategies or public health policies (alphabetically ordered) are the Czech Republic, Germany, Ireland, the Netherlands and the United Kingdom.

109 Federal Ministry of Education and Research, *The High-Tech Strategy 2020*, 2006, http://www.bmbf.de/en/6618.php.

110 The German Health Research Council, Federal Ministry of Education and Research, *Roadmap for the German Health Research Program of the Federal Government, Executive Summary*, August 2007, http://www.bmbf.de/pubRD/Roadmap_Summary.pdf.

111 The Germany Federal Ministry of Education and Research, *Health Research Framework Programme of the Federal Government*, 2010, http://www.bmbf.de/pub/health_research_framework_programme.pdf.

112 Medical Research Council, *Research changes lives*, London, 2006, pp. 2-3.

113 STEPS, *Country profile UK*, 2010, http://www.steps-ph.eu/wp-content/uploads/United-Kingdom_STEPS_countryprofile_22-Aug-2011.pdf, p. 8.

114 *Global R&D Financing for Communicable and Noncommunicable Diseases*, A Report to the WHO Expert Working Group on R&D Financing, October 2009.

115 Data for this part of the report is drawn from the World Health Organization (WHO) databases and regional offices, the International Monetary Fund (IMF) databases on public health (expenditure), Organization for Cooperation and Development (OECD) databases, the CORDIS database of the European Commission, the European Commission Directorate-General for Research, Research & Innovation, the IIMS ERAWATCH information platform on European, national and regional research systems and policies, the STEPS (Strengthening Engagement in *Public Health* Research) project and data from the Public Health Innovation & Research in Europe (PHIRE) project.

116 EU Research, 'Research Themes within the Thematic Programmes of FP7', http://www.euresearch.ch/index.php?id=69.

117 European Commission, Community Research and Development Information Service (CORDIS), 'Health Research', http://cordis.europa.eu/FP7/health/.

118 'Health - FP7 - Research - Europa', n.d., http://ec.europa.eu/research/FP7/index_en.cfm?pg=health.

119 Innovative Medicines Initiative, 'Home | IMI - Innovative Medicines Initiative.'

120 European Commission, Research & Innovation – Health, Biotechnology, Tools and Technologies, 'Biomedical Technologies - FP7 Projects,' http://ec.europa.eu/research/health/biotechnology/biomedicaltechnologies/ index_en.html.

121 European Commission, Research & Innovation – Health, Biotechnology, Tools and Technologies, 'Diagnostics and Imaging - FP7 Projects", http://ec.europa.eu/research/health/biotechnology/diagnostics/index_en.html.

122 European Commission, Research & Innovation – Health, Biotechnology, Tools and Technologies, 'New Therapies and Immunization Strategies - FP7 Projects,' http://ec.europa.eu/research/health/biotechnology/new-therapies/index_en.html.

123 European Commission, Research & Innovation – Health; Biotechnology, Tools and Technologies, 'Alternative Testing Strategies - FP7 Projects,' http://ec.europa.eu/research/health/biotechnology/alternative-testingstrategies/ index_en.html.

124 European Commission, 'Omics - Large-scale Data Gathering and Systems Medicine - Health - Research - European Commission.'

125 European Commission, 'Model Organisms - Large-scale Data Gathering and Systems Medicine - Health - Research - European Commission.'

126 European Commission, 'Systems Medicine - Large-scale Data Gathering and Systems Medicine - Health - Research - European Commission,' http://ec.europa.eu/research/health/large-scale/systemsmedicine/ index_en.html.

127 European Commission, 'Human Development and Ageing - Projects.'

128 European Commission, 'Brain Research - Projects.'

129 European Commission, 'Cancer.'

130 European Commission, 'Cardiovascular Diseases.'

131 European Commission, 'Diabetes and Obesity - Projects.'

132 European Commission, 'Severe Chronic Diseases.'

133 European Commission, 'Clinical Research into Practice.'

134 European Commission, 'Health Systems Research.'

135 European Commission, 'Health Promotion and Disease Prevention.'

136 European Commission, 'International Public Health and Health Systems.'

137 European Commission, 'Systems Medicine - Large-scale Data Gathering and Systems Medicine - Health - Research - European Commission.'

138 Horizon 2020 is the financial instrument which supports the implementation of the Innovation Union, a Europe 2020 flagship project. 'The EU Framework Programme for Research and Innovation - Horizon 2020 - the Framework Programme for Research and Innovation - European Commission', n.d., http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020.

139 'Work Program 2011-2012,' *European Commission, CORDIS, FP7 ICT Information and Communication Technologies*, n.d., ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/ict-wp-2011-12_en.pdf.

140 Ibid., 65–73.

141 'Work Program 2008,' *European Commission, CORDIS, FP7 Nanosciences, Nanotechnologies, Materials and New Production Technologies*, n.d., 16–17, http://ec.europa.eu/research/participants/portalplus/static/docs/calls/fp7/fp7-nmp-2008-large-2/22236- d_wp_200801_en.pdf.

142 'Environment and Health,' *European Commission, Directorate-General for Research, Research & Innovation*, n.d., http://ec.europa.eu/research/environment/index_en.cfm?pg=health.

143 European Parliament and Council of European Union, 'Decision N° 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 Concerning the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (2007-2013)' (Official Journal of the European Union, December 18, 2006), http://eurlex. europa.eu/LexUriServ/site/en/oj/2006/l_412/l_41220061230en00010041.pdf.

144 'European CommissionÐ: CORDISÐ: FP7Ð: Food, Agriculture and Fisheries, and BiotechnologyÐ: Home', n.d., http://cordis.europa.eu/fp7/kbbe/home_en.html.

145 *Fork to Farm: Food (including Seafood), Health and Wellbeing – A Guide to FP7 Research Within Activity 2.2.* (European Commission, CORDIS, FP7, Food, Agriculture and Fisheries, and Biotechnology, n.d.), ftp://ftp.cordis.europa.eu/pub/fp7/kbbe/docs/fiche-food-080305_en.pdf.

146 'EAHC - Health Programme - Funded Projects,' *European Commission*, n.d., http://ec.europa.eu/eahc/health/funded_projects.html.

147 European Commission, *White Paper - Together for Health: A Strategic Approach for the EU 2008-2013* (Brussels: European Union, October 23, 2007), http://ec.europa.eu/health-eu/doc/whitepaper_en.pdf. Funded Projects: The objectives of the program are implemented through the use of annual work plans.

148 Competitiveness and Innovation Framework Programme 2007-2013, 'Factsheet: WHAT IS CIP? Increasing Competitiveness Through Innovation', n.d., http://ec.europa.eu/cip/files/docs/factsheets_en.pdf.

149 The European Innovation Partnership on Active and Healthy Aging, http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-ageing.

150 'Health & Wellbeing - EIT ICT Labs', n.d., http://www.eitictlabs.eu/action-lines/health-wellbeing/.

151 'About EIT ICT Labs - EIT ICT Labs', n.d., http://www.eitictlabs.eu/ict-labs/about-eit-ict-labs/.

152 'The Challenge — ETP Nanomedicine', n.d., http://www.etp-nanomedicine.eu/public/about/objectivesmission.

153 Net!Works, *Connecting Health Applications for a Smarter Society, Position Paper*, July 12, 2010, http://www.networksetp. eu/fileadmin/user_upload/Publications/Position_White_Papers/health_final071210.pdf.

154 Mary Anne Burke and Stephen A Matlin (eds.), Global Forum for Health Research, *Monitoring Financial Flows for Health Research,* 2008.

155 *Global R&D Financing for Communicable and Noncommunicable Diseases*, A Report to the WHO Expert Working Group on R&D Financing, October 2009.

156 Ibid.

157 World Economic Forum, *The Global Economic Burden of Non-communicable Diseases* (World Economic Forum, September 2011), http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf. The approach distinguishes between direct and indirect costs of different health conditions. Direct costs refer to visible costs associated with diagnosis, treatment, and care. Indirect costs refer to the invisible costs associated with lost productivity and income owing to disability or death.

158 Ibid., p.39.

159 The European Federation of Pharmaceutical Industries and Associations (EFPIA), *The Pharmaceutical Industry in Figures, Key Data 2012*, 2012, http://www.efpia.eu/sites/www.efpia.eu/files/EFPIA_Figures_2012_Final-20120622-003-EN-v1.pdf.

160 *OECD science, technology and industry scoreboard 2009.* (Paris: OECD, 2009).

161 *Monitoring Financial Flows for Health Research,* 2008.

162 Marta Feletto and Stephen A Matlin, *Global R&D Financing for Communicable and Noncommunicable Diseases*, A Report to the WHO Expert Working Group on R&D Financing, October 2009, www.who.int/phi/GlobalRandDFinanceCDsNCDs.doc.

163 Large pharmaceutical groups struggle to find lucrative replacements for these drugs. What is more, developing drugs has become a more complex, therefore an increasingly expensive process. The IMS Institute for Healthcare Informatics, *The Global Use of Medicines: Outlook Through 2010*, July 2012, http://www.imshealth.com/deployedfiles/ims/Global/Content/Insights/IMS%20Institute%20for%20Healthcare%20Informatics/Global%20Use%20of%20Meds%202011/Medicines_Outlook_Through_2016_Report.pdf.

164 Ibid.

165 Richard Sullivan et al., 'Using bibliometrics to inform cancer research policy and spending', in *Monitoring Financial Flows for Health Research 2007*, Global Forum for Health Research, 2007, http://www.isn.ethz.ch/isn/Digital-Library/Publications/Detail/?ots591=0c54e3b3-1e9c-be1e-2c24-a6a8c7060233&lng=en&id=93422.

166 Pharmaceutical Research and Manufacturers of America (PhRMA) Chart Pack, *Biopharmaceuticals in Perspective*, Spring 2012, p.16, http://www.phrma.org/sites/default/files/159/phrma_chart_pack.pdf

167 The IMS Institute for Healthcare Informatics, The Global Use of Medicine: Global Outlook Through 2015, 2011, http://www.imshealth.com/deployedfiles/ims/Global/Content/Insights/IMS%20 Institute%20for%20Healthcare %20Informatics/Global_Use_of_Medicines_Report.pdf.

168 The Irish Pharmaceutical Healthcare Association (IPHA), 'New Medicines in Development', http://www.ipha.ie/alist/new-medicines-in-development.aspx.

169 Julie Steenhuysen, 'Alzheimer's Drug Crenezumab Picked for Major Test,' *Health News*, May 15, 2012, http://www.healthnews.com/en/news/Alzheimers-drug-crenezumab-picked-for-majortest/1C4TJyigX9qum_O_oW6iRg/.

170 Boehringer Ingelheim, 'New data demonstrate sustained glucose reduction and weight loss up to 90 weeks with investigational SGLT-2 inhibitor, Empagliflozin', June 9, 2012, http://www.boehringeringelheim.com/news/news_releases/press_releases/2012/09_june_2012_empagliflozin.html

171 Europe INNOVA InJection project, Interlace-Invent, *Segmentation Framework for the Medical Device Sector*, EU Sixth Framework Programme Priority, 2006.

172 Ibid.

173 John Wilkinson, Eucomed, 'The medical technology industry in Europe', Brussels, May 25, 2011, http://www.eucomed.org/uploads/Modules/Publications/1100929_the_medical_technology_industry_in_eur ope-2.pdf. Ernst & Young Medtech, 'Pulse of the Industry Medical Technology Report 2010', April 2010, BioCom DeviceFest.

174 'The medical technology industry in Europe', 2011.

175 OECD, 'Health innovation', in *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing http://dx.doi.org/10.1787/sti_scoreboard-2011-35-en.

176 *Spurring the Market for High-tech Home Health Care* (Mc Kinsey Quarterly, September 2011), http://www.mckinseyquarterly.com/Health_Care/Strategy_Analysis/Spurring_the_market_for_hightech_ home_health_care_2856.

177 'Demographic Change - Technologies for Seniors: Coming Home,' *Siemens*, n.d., http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2010/_html_en/custom-implants.html.

178 'Demographic Change and Robotics: I, Butler,' *Siemens, Pictures of the Future*, Fall 2010, http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2010/_html_en/i-butler.html.

179 The Economist Intelligence Unit, *A Silver Opportunity? Rising longevity and its implications for business*, 2011, p. 15. Philips, Corporate website, Resident Safety Products, http://philipsseniorliving.com/content/lifesafety- products/life.jsp.

180 'About Health Research and Innovation,' *Intel*, n.d., http://www.intel.com/corporate/europe/emea/irl/intel/health care/index.htm.

181 *Monitoring Financial Flows for Health Research,* 2008.

182 *Global R&D Financing for Communicable and Noncommunicable Diseases*, A Report to the WHO Expert Working Group on R&D Financing, October 2009.

183 Global Forum for Health Research, *Global Forum Update on Research for Health. Health Research to Achieve the Millennium Development Goals*, 2005, http://announcementsfiles.cohred.org/gfhr_pub/assoc/s14809e/s14809e.pdf.

184 The Wellcome Trust, *Strategic Plan 2010-2020: Extraordinary activities*, http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/WTDV027438.pdf; The Wellcome Trust, Annual Review: Support for the Brightest Minds, 2011, http://www.wellcome.ac.uk/stellent/groups/corporatesite/@sf_cross_cutting_activities/documents/web_document/wtvm053884.pdf.

185 European Commission, *Giving more for research in Europe: The role of foundations and the non-profit sector in boosting R&D investment*, 2005, http://ec.europa.eu/invest-inresearch/pdf/download_en/rec_5_7800_giving_4_051018_bat.pdf.

186 *Spurring the Market for High-tech Home Health Care* (Mc Kinsey Quarterly, September 2011), http://www.mckinseyquarterly.com/Health_Care/Strategy_Analysis/Spurring_the_market_for_hightech_home_health_care_2856.

187 *Most-Cited Journals in Aging Research Ranked by Citations to Papers Published and Cited Between 1999 and 2010* (Lab Times, April 2012), http://www.labtimes.org/labtimes/issues/lt2012/lt04/lt_2012_04_32_34.pdf.

188 See our online GeoRisQ Monitor on aging *'Shades of Graying'* for more detail. It will be published in January 2013 on our website: http://projects.hcss.nl/monitor/.

189 Jos. Ignacio de Granda-Orive et al., 'Spanish Productivity in Smoking Research Relative to World and European Union Productivity From 1999 Through 2003, Analyzed with the Science Citation Index', *Arch Bronconeumol*, 2007, Vol. 43, N°4., pp. 212-8.

190 Joanna E. Cohen, Michael O. Chaiton, Lynn C. Planinac, 'Tacking Stock. A Bibliometric Analysis of the Focus of Tobacco Research from the 1980s to the 2000s', *American Journal of Preventive Medicine*, 2010, Vol. 39, N°4, pp. 352-356.

191 J. Vioque, J.M. Ramos, E.M. Navarrete-Mu.oz, and M. Garcia de la Hera, 'A bibliometric study of scientific literature on obesity research in PubMed (1988-2007)', *Obesity Reviews, International Association for the Study of Obesity*, 2009.

192 R. Rajendram et al., 'Worldwide Alcohol-Related Research and the Disease Burden', *Alcohol and Alcoholism*, 2006, Vol. 41, N°1, pp. 99-106.

193 S. M. Tarkowski, 'Environmental Health Research in Europe Bibliometric Analysis,' *The European Journal of Public Health* 17, no. Supplement 1 (January 1, 2007): 14–18.

194 Richard Sullivan et al., 'Using bibliometrics to inform cancer research policy and spending', in *Monitoring Financial Flows for Health Research 2007*, Global Forum for Health Research, 2007, http://www.isn.ethz.ch/isn/Digital-Library/Publications/Detail/?ots591=0c54e3b3-1e9c-be1e-2c24- a6a8c7060233&lng=en&id=93422.

195 Ronan W. Glynn et al., 'Representation of Cancer in the Medical Literature - A Bibliometric Analysis', 2010, PLoS ONE, Vol. 5, N° 10, http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0013902.

196 'Using bibliometrics to inform cancer research policy and spending', in *Monitoring Financial Flows for Health Research 2007*.

197 *Most-Cited Journals in Cancer Research Ranked by Citations to Papers Published and Cited Between 1998 and 2009* (Lab Times, January 2012) http://www.labtimes.org/labtimes/issues/lt2012/lt01/lt_2012_01_40_42.pdf

198 International Agency for Research on Cancer, 'GLOBOCAN 2008', 2008, http://globocan.iarc.fr/.

199 *Most-Cited Journals in Cardiovascular and Circulation Research Ranked by Citations to Papers Published and Cited Between 1996 and 2007* (Lab Times, February 2009), http://www.labtimes.org/labtimes/ranking/2009_02/index.lasso.

200 D. Ugolini et al, 'A Bibliometric Analysis of Literature in Cerebrovascular and Cardiovascular Diseases Rehabilitation: Growing Numbers, Reducing Impact Factor', 2012, published in Elsevier, http://www.archivespmr. org/article/S0003-9993%2812%2900882-9/abstract.

201 Vincent Larivi.re, INMHA and RAND Europe, *Bibliometric review of mental health research*, http://www.grahamboeckhfoundation.org/news/bibliometric-review-mental-health-research.

202 Vincent Larivi.re et al., *Bibliometric Analysis of INMHA-related Research, 1997-2008*, Observatoire des Sciences et des Technologies, September 2010.

203 Source : OECD and European Commission.

204 Stephen A. Matlin, *Research for health: The backbone of health equity and sustainable, robust health systems*, Health G20 Book, 2011 edition, http://healthg20.com/wp-content/uploads/2011/11/115-128-Stephen-A-Matlin.pdf.

205 The Commission on Social Determinants of Health, *Closing the gap in a generation: Health equity through action on the social determinants of health*, WHO, 2008, http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf.

206 Louise Bouchard, Marcelo Albertini, and Ricardo Batista, University of Ottawa, 'Bibliometric study on health inequalities research', *Transdisciplinary Studies in Population Health Series*, Vol. 3, N°2, 2012.

207 Federal Ministry of Education and Research (BMBF), Health Research Division, *Health Research Framework Programme of the Federal Government*, 2010; *European Research for a Healthier Future* (European Commission, October 2011); Strengthening Engagement in Public Health Research, *STEPS Report: Public Health Research – Europe's Future*.

208 *Researching: Health*; European Commission, *White Paper - Together for Health: A Strategic Approach for the EU 2008-2013* (Brussels: European Union, October 23, 2007), http://ec.europa.eu/healtheu/doc/whitepaper_en.pdf; 'Countries' Long-term National Strategies for Public-health

Research: Survey of National Ministries in European Countries – Responses on Current Public-health Research Priorities', 2009; Mark McCarthy et al., 'Comparing Public-health Research Priorities in Europe,' *Health Research Policy and Systems* 7, no. 17 (2009), http://www.health-policy-systems.com/content/7/1/17.

209 Alliance of Scientific Organizations, *Researching: Health*, July 2011, p.19, http://www.dfg.de/download/pdf/dfg_im_profil/geschaeftsstelle/publikationen/alliance_researching_health.pdf.

210 World Health Organization, Preamble to the Constitution of the World Health Organization as Adopted by the International Health Conference (New York, April 7, 1948).

211 Machteld Huber et al., 'How Should We Define Health?', *British Medical Journal*, July 2011, N°343, http://static.ow.ly/docs/como%20definimos%20la%20salud_kW8.pdf.

212 R., Smith, 'The end of disease and the beginning of health', BMJ Group Blogs, 2008, http:/ /blogs.bmj.com/bmj/2008/07/08/richard-smith-the-end-of-disease-and-the-beginning-ofhealth/.

213 Huber et al., 'How Should We Define Health?'.

214 IBM Institute for Business Value, Health care 2015 and Care Delivery - Delivery Models Refined, Competencies Defined.

215 Machteld Huber, Invitational Conference 'Is Health a State or an Ability? Towards an Dynamic Concept of Health', Report of the meeting December 10-11, 2009, May 2010, The Netherlands Organization for Health Research and Development and the Health Council of the Netherlands, www.gezondheidsraad.nl/sites/default/files/bijlage%20A1004_1.pdf; Huber et al., 'How Should We Define Health?'.

216 Ibid.

217 Bernard C.K. Choi and Anita W.P. Pak, 'Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness', *Clinical and Investigative Medicine*, December 2006, Vol. 29, N°6, http://courseweb.edteched.uottawa.ca/pop8910/PDF%20Files/Choi_Multidisciplinary.pdf.

218 Kalpana M. Nair et al., 'It's all about relationships: A qualitative study of health researchers' perspectives of conducting interdisciplinary health research', *BMC Health Services Research,* 2008, Vol. 8, N°110, http://www.biomedcentral.com/1472-6963/8/110/.

219 Jan van de Greef and Herman van Wietmarschen, 'Systeemdenken als basis voor duurzame gezondheidszorg', in Marko van Gerven, Jan Huisman, Hans Nijnens et al., *Duurzame Gezondheidszorg. Druk 1: Visies En Praktijkervaringen*, Christofoor, 2011, pp. 171-186.

220 Jan van de Greef and Herman van Wietmarschen, 'Systeemdenken als basis voor duurzame gezondheidszorg', in Marko van Gerven, Jan Huisman, Hans Nijnens et al., *Duurzame Gezondheidszorg. Druk 1: Visies En Praktijkervaringen*, Christofoor, 2011, pp. 171-186; Stephen A. Matlin, *Research for health: The backbone of health equity and sustainable, robust health systems*, Health G20 Book, 2011 edition, http://healthg20.com/wp-content/uploads/2011/11/115-128-Stephen-A-Matlin.pdf.

221 PriceWaterhouseCoopers Health Research Institute, *Build and Beyond: The (r) evolution of healthcare PPPs*, December 2010, http://download.pwc.com/ie/pubs/2010_build_and_beyond.pdf.

222 Dr. Ruxandra Draghia-Akli and European Commission, Directorate-General for Research and Innovation, Health Directorate, 'The EU Edge in Cancer Research', n.d., https://espace.cern.ch/ICTR-PHE2012-slides/Session%201%20Radiobiology%20in%20therapy%20and%20space%20scienc/ECDirector_ICTR-PHEGeneva_27%2002%202012_Final.pdf.

223 PriceWaterhouseCoopers *Build and Beyond: The (r) evolution of healthcare PPPs*.

224 Stockholm County Council, New Karolinska Solna, 'Swedish – British consortium to build New Karolinska University Hospital in Stockholm', 2011, http://www.nyakarolinskasolna.se/en/The-New-Hospital/News-at- NKS/Swedish--British-consortium-to-build-New-Karolinska-University-Hospital-in-Stockholm/.

225 Irina A. Nikolic and Harald Maikisch, *Public-Private Partnerships and Collaboration in the Health Sector: An Overview with Case Studies from Recent European Experience*, Discussion Paper (Health, Nutrition and Population Family (HNP), World Bank's Human Development Network; The International Bank for Reconstruction and Development, The World Bank, October 2006), http://siteresources.worldbank.org/INTECAREGTOPHEANUT/Resources/HNPDiscussionSeriesPPPPaper.pdf.

226 Sania Nishtar, 'Public – private 'partnerships' in health – a global call to action', *Health Research Policy* and *Systems*, 2004, Vol. 2, N°5, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC514532/.

227 Kristine M. Gebbie et al., 'Training for Interdisciplinary Health Research: Defining the Required Competencies', Journal of Allied Health, 2008, Vol. 37, N°2, pp. 65-70, http://www.asph.org/userfiles/Comps- Gebbie-TrainingInterdisciplinaryHealthResearch.pdf.

228 World Health Summit, 'We need a closer health alliance', Berlin, October 26, 2011, http://www.worldhealthsummit.org/fileadmin/media/press/2009/WHS%202011%20PM%20Final%20Day%20eng.pdf.

229 Bernard C.K. Choi and Anita W.P. Pak, 'Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness', *Clinical and Investigative Medicine*, December 2006, Vol. 29, N°6, http://courseweb.edteched.uottawa.ca/pop8910/PDF%20Files/Choi_Multidisciplinary.pdf.

230 Dr. Gerard Lyons, Biomedical Electronics Laboratory, Department of Electronic and Computer Engineering, University of Limerick, 'Multidisciplinary Research', 2004, http://www.hse.ie/eng/staff/Leadership_Education_Development/National_Institute_of_Health_Sciences/NIHS_PDFs/Multi-disciplinary_Research.pdf . Weill Cornell Medical College, Division of General Internal Medicine, http://vivo.cornell.edu/display/individual6901.

231 The American Federation for Aging Research (AFAR), 'Grant Program aims to spur new avenues of research on Alzheimer's disease by encouraging collaboration', June 18, 2012, http://www.afar.org/docs/Press_Release_2012_Collaborative_Research_Awards.pdf.

232 Olivia Koski, 'Interdisciplinary Research Partnerships Set Out to Uncover the Physics of Cancer', Scientific American, December 27, 2010, http://www.scientificamerican.com/article.cfm?id=psoc-physics-oncology.

233 Richard Coker, Rifat Atun, and Martin McKee, *Health systems and the challenge of communicable disease* (New York: 2008): 131.

234 Scott J. Leischow et al., 'System thinking to improve the public's health,' American Journal on Preventive Medicine No. 35 (2008): 196.

235 Ibid.

236 De Visser, Ellen, 'Voorgeschreven maar te licht bevonden', Volkskrant, September 22, 2012.

237 Duke Personalized Medicine, Duke University, http://www.dukepersonalizedmedicine.org/what_is_personalized_medicine/.

238 Jan van de Greef and Herman van Wietmarschen, 'Systeemdenken als basis voor duurzame gezondheidszorg', in Marko van Gerven, Jan Huisman, Hans Nijnens et al., *Duurzame Gezondheidszorg. Druk 1: Visies En Praktijkervaringen*, Christofoor, 2011, pp. 171-186.

239 The Ohio State University Medical Center, 'Lessons for the Future of Personalized Health Care', 2008, http://medicalcenter.osu.edu/pdfs/cphc/PHC_Conference_White_Paper.pdf.

240 Envisioning Technology, 'Envisioning the Future of Health Technology.'

241 *Healthy Lives, Healthy People: Our Strategy for Public Health in England*, White Paper (UK Government, November 2010); Federal Ministry of Education and Research (BMBF), Health Research Division, *Health Research Framework Programme of the Federal Government*, Germany, 2010.

242 Greater Bonston Physicians for Social Responsibility and Science and Environmental Health Network, *Health Environmental threats to Healthy Aging – With a Closer Look at Alzheimer's and Parkinson's Diseases*, 2008, http://www.agehealthy.org/pdf/GBPSRSEHN_HealthyAging1017.pdf.

243 Alliance of Scientific Organizations, *Researching: Health*, July 2011, p.19, http://www.dfg.de/download/pdf/dfg_im_profil/geschaeftsstelle/publikationen/alliance_researching_health.pdf.

244 Ibid.

245 De Visser, Ellen, 'Voorgeschreven maar te licht bevonden', Volkskrant, September 22, 2012.

246 Singh, How Can Chronic Disease Management Programmes Operate Across Care Settings and Providers?.

247 Ruth Puttick, *Innovations in Prevention*, Nesta Operating Company, October 2012, http://www.nesta.org.uk/library/documents/InnovationsinPrevention.pdf.

248 Pieter H. M. van Baal et al., 'Lifetime Medical Costs of Obesity: Prevention No Cure for Increasing Health Expenditure,' PLoS Med 5, no. 2 (2008), http://www.plosmedicine.org/

article/info%3Adoi%2F10.1371%2Fjournal.pmed.0050029; Division for Heart Disease and Stroke Prevention, Centers for Disease Control and Prevention, 'Benefit-Cost Analysis of Prevention', n.d., -, http://www.cdc.gov/dhdsp/programs/nhdsp_program/economic_evaluation/Module_IV/Podcast_IV.pdf.

249 The Hague Centre for Strategic Studies (HCSS), TNO and Delft University of Technology (TU Delft), *Aging: Uncertainties and Solutions. An Exploration of Scenarios, Problems and Solutions with Respect to the Affordability of Societal Aging*, The Hague, September 2012, http://www.hcss.nl/reports/aging-uncertaintiesand- solutions/109/, p.35.

250 World Economic Forum, *Global Risks 2010*, 2011, p. 25, http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2010.pdf.

251 Ibid.

252 'Tax Policy: Who Pays for Our Sins?,' The Economist (New York, June 10, 2010), Online edition, http://www.economist.com/blogs/freeexchange/2010/06/tax_policy.

253 The Hague Centre for Strategic Studies (HCSS), TNO and Delft University of Technology (TU Delft), *Aging: Uncertainties and Solutions. An Exploration of Scenarios, Problems and Solutions with Respect to the Affordability of Societal Aging*, The Hague, September 2012, http://www.hcss.nl/reports/aging-uncertaintiesand- solutions/109/, p.9.

254 Dana P. Goldman et al., 'The Benefits of Risk Factor Prevention in Americans Aged 51 Years and Older', American Journal of Public Health, Vol. 99, N°11, November 2009, pp. 2096-2101, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2759785/. http://www.bepress.com/fhep/biomedical_research/1.

255 Ying Liu, Three Essays on Hypertension Prevention and Medical Product Safety in China and the United States, the Pardee RAND Graduate School (PRGS) dissertation series, December 2009, http://www.rand.org/content/dam/rand/pubs/rgs_dissertations/2010/RAND_RGSD254.pdf.

256 Joel Shalowitz, 'Financing Chronic Care Seminar: Chronic Vs. Acute Care, Introduction and Macro View', 2005, www.soa.org/library/monographs/ ./chronic ./m-hb05-1_viii.aspx.

257 IBM Institute for Business Value, Health care 2015 and Care Delivery - Delivery Models Refined, Competencies Defined.

258 Proctor P Reid et al., Building a better delivery systemÐ: a new engineering/health care partnership (Washington, D.C.: National Academies Press, 2005).

259 Ernst & Young, *Pulse of the Industry: Medical technology report*, 2012, http://www.ey.com/Publication/vwLUAssets/Pulse_medical_technology_report_2012/$FILE/Pulse_medical_technology_report_2012.pdf.

260 Federal Ministry of Education and Research (BMBF), Health Research Division, *Health Research Framework Programme of the Federal Government*, 2010; *European Research for a Healthier Future* (European Commission, October 2011); Strengthening Engagement in Public Health Research, *STEPS Report: Public Health Research – Europe's Future*.

261 Milken Institute, *An Unhealthy America: The Economic Burden of Chronic Diseases. Charting a New Course to Save Lives and Increase Productivity and Economic Growth*. Executive Summary and Research Findings, October 2007, http://www.milkeninstitute.org/healthreform/pdf/AnUnhealthyAmericaExecSumm.pdf. David Leonhardt, 'Greg Mankiw on the Soda Tax,' New York Times, Economix Blog, June 7, 2010, http://economix.blogs.nytimes.com/2010/06/07/greg-mankiw-on-the-soda-tax/.

262 European Union Health Policy Forum, Answer to DG SANCO Consultation on Chronic Diseases.

263 Global Forum for Health Research, *Monitoring Financial Flows for Health Research,* 2008, p. 5.

264 Federal Ministry of Education and Research (BMBF), Health Research Division, *Health Research Framework Programme of the Federal Government*, Germany, 2010; http://www.bmbf.de/pub/health_research_framework_programme.pdf.

265 *European Research for a Healthier Future* (European Commission, October 2011), http://www.gppq.mctes.pt/_7pq/_docs/brochuras/online/european-research-2008_en.pdf; Strengthening Engagement in Public Health Research, *STEPS Report: Public Health Research – Europe's Future*.

266 The Hague Centre for Strategic Studies (HCSS), TNO and Delft University of Technology (TU Delft), *Aging: Uncertainties and Solutions. An Exploration of Scenarios, Problems and Solutions with Respect to the Affordability of Societal Aging*, The Hague, September 2012, http://www.hcss.nl/reports/aging-uncertaintiesand- solutions/109/, p.9.

267 'The Cost of Dying: End-of-Life Care,' CBS News, August 8, 2010, Online edition, http://www.cbsnews.com/2100-18560_162-6747002.html?tag=contentMain;contentBody.

268 James C. Robinson and Mark D. Smith, 'Cost-Reducing Innovation In Health Care', *Health Affairs*, September 2008, Vol. 27, N°5, pp. 1353-1356, http://content.healthaffairs.org/content/27/5/1353.full.

269 Jason Hwang, and Clayton M. Christensen, 'Disruptive Innovation in Health Care Delivery: A Framework for Business-Model Innovation', *Health Affairs*, Vol. 27, N° 5, 2008, http://content.healthaffairs.org/content/27/5/1329.full.pdf+html.

270 The Deloitte Center for Health Solutions, 'The Mobile Personal Health Record: Technology-Enabled Self- Care: Barriers and opportunities to accelerate use', Issue Brief, 2010, http://www.deloitte.com/view/en_US/us/Industries/US-federal-government/center-for-healthsolutions/research/19472c5a9ddaa210VgnVCM2000001b56f00aRCRD.htm.

271 Mary Anne Burke and Stephen A Matlin (eds.), Global Forum for Health Research, *Monitoring Financial Flows for Health Research,* 2008, p. 5.

272 National Center for HIV/AIDS, Viral Hepatitis, STD and TB prevention, *Establishing a Holistic Framework to Reduce Inequities in HIV, Viral Hepatitis, STDs, and Tuberculosis in the United States,* An NCHHSTP White Paper on Social Determinants of Health, 2010, http://www.bmbf.de/pub/health_research_framework_programme.pdfhttp://www.cdc.gov/socialdeterminants/docs/sdh-white-paper-2010.pdf.

273 *Monitoring Financial Flows for Health Research,* 2008, p. 30. Lasse Tarkiainen, Pekka Martikainen, Mikko Laaksonen, Tapani Valkonen, 'Trends in life expectancy by income from 1988 to 2007: decomposition by age and cause of death', The Journal of *Epidemiology* and *Community Health,* 2012, N°66, pp. 573-578.

274 S.V. Subramanian and Ichiro Kawachi, 'Income Inequality and Health: What Have We Learned So Far?', Epidemiologic Reviews, Vol. 26, N°1, 2004, pp. 78-91, http://epirev.oxfordjournals.org/content/26/1/78.full. Karen Rowlingson, 'Does income inequality cause health and social problems?', Joseph Rowntree Foundation, September 2011, http://www.jrf.org.uk/sites/files/jrf/inequality-income-social-problems-summary.pdf.

275 University of Chicago, 'Jens Ludwig elected to prestigious Institute of Medicine for research on social determinants of health', October 15, 2012, http://news.uchicago.edu/article/2012/10/15/jens-ludwig-electedprestigious-institute-medicine.

276 University of Liverpool, Institute of Psychology, Health and Society, Research Group: Social Determinants and Health Inequalities, http://www.liv.ac.uk/psychology-health-and-society/research/social-determinantsand-health-inequalities/.

277 *Monitoring Financial Flows for Health Research,* 2008, p. 30.

278 The Commission on Social Determinants of Health, *Closing the gap in a generation: Health equity through action on the social determinants of health*, WHO, 2008, http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf; Mary Anne Burke and Stephen A Matlin (eds.), Global Forum for Health Research, *Monitoring Financial Flows for Health Research,* 2008, p. 5; Mackenbach JP., *Health inequalities: Europe in profile*, London, UK Presidency of the EU 2005, http://ec.europa.eu/health/ph_determinants/socio_economics/documents/ev_060302_rd06_en.pdf); Judge K, Platt S, Costongs C, Jurczak K., *Health inequalities: a challenge for Europe*, UK Presidency of the EU 2005, http://www.britishembassy.gov.uk/Files/kfi le/HI_EU_Challenge,0.pdf).

279 Mackenbach JP., *Health inequalities: Europe in profile*, London, UK Presidency of the EU 2005, http://ec.europa.eu/health/ph_determinants/socio_economics/documents/ev_060302_rd06_en.pdf); Judge K, Platt S, Costongs C, Jurczak K., *Health inequalities: a challenge for Europe*, UK Presidency of the EU 2005, http://www.britishembassy.gov.uk/Files/kfi le/HI_EU_Challenge,0.pdf).

280 Proposal for a Regulation of the European Parliament and of the Council on Establishing a Health for Growth Programme, the Third Multi-annual Programme of EU Action in the Field of Health for the Period 2014-2020.

281 Health Research Framework Programme of the Federal Government; Major Trends, Challenges and Emerging Issues in Health; Proposal for a Regulation of the European Parliament and of the Council on Establishing a Health for Growth Programme, the Third Multi-annual Programme of EU Action in the Field of Health for the Period 2014-2020; European Foresight Monitoring Network, Special Issue on Healthcare: Healthy Ageing and the Future of Public Healthcare Systems (Brussels: European Commission, European Research Area, European Foresight Monitoring Network, November 2009), http://ec.europa.eu/research/socialsciences/pdf/efmn-special-issue-on-healthcare_en.pdf; Cl.udia Concei..o, Alexandra Leandro, and Mark McCarthy, 'National

Support to Public Health Research: a Survey of European Ministries,' BMC Public Health 9, no. 203 (2009), http://www.biomedcentral.com/1471-2458/9/203; Concei..o and McCarthy, 'Public Health Research Systems in the European Union'; European Action Plan for Strengthening Public Health Capacities and Services, Draft (World Health Organization, Regional Office for Europe, February 17, 2012).

282 Zsuzsanna Jakab, WHO Regional Director for Europe, 'Patient Empowerment in the European Region - A Call for Joint Action' (presented at the First European Conference on Patient Empowerment, Copenhagen, April 11, 2012), http://www.euro.who.int/__data/assets/pdf_file/0016/162232/RDs-Opening-speech-Patient-Empowerment.pdf.

283 The World Bank, 'Mortality Rate, Infant (per 1,000 Live Births)', 2011, http://data.worldbank.org/indicator/SP.DYN.IMRT.IN.

284 'Health Statistics and Health Information Systems. Health Status Statistics: Mortality - Neonatal Mortality Rate (per 1000 Live Births),' *World Health Organization*, n.d., http://www.who.int/healthinfo/statistics/indneonatalmortality/en/.

285 'Adult Mortality Rate (probability of Dying Between 15 to 60 Years Per 1000 Population),' *World Health Organization*, n.d., http://apps.who.int/gho/indicatorregistry/App_Main/view_indicator.aspx?iid=64.

286 'Health Statistics and Health Information Systems. Health Status Statistics: Mortality - Healthy Life Expectancy (HALE),' *World Health Organization*, n.d., http://www.who.int/healthinfo/statistics/indhale/en/.

287 Whereas the UN Millennium Goals assess the improvement of health through indicators of access to 'primary health care, including immunization, sanitation, access to safe drink water, and safe motherhood initiatives', other organizations tend to also include the average life expectancy at birth, infant mortality rate and the prevalence of preventable diseases or premature deaths as indicators of health status. The World Bank database provides indicators that cover 'health systems, disease prevention, reproductive health, nutrition, and population dynamics'. Sources: Ibid.; 'The World Bank Database: Health,' *The World Bank*, n.d., http://data.worldbank.org/topic/health.

288 The World Bank, 'Mortality Rate, Infant (per 1,000 Live Births).'

289 Ibid.

290 'Adult Mortality Rate (probability of Dying Between 15 to 60 Years Per 1000 Population).'

291 'Health Statistics and Health Information Systems. Health Status Statistics: Mortality - Healthy Life Expectancy (HALE),' *World Health Organization*, n.d., http://www.who.int/healthinfo/statistics/indhale/en/.

292 World Health Organization, 'WHO | Global Health Observatory Data Repository', 2011, http://apps.who.int/ghodata/?vid=10011#.

293 The term 'Western world' is used in its cultural meaning and includes the EU, Northern America, Australia, and New Zealand.

294 World Health Organization, *Global status report on noncommunicable diseases 2010* (Geneva, Switzerland: World Health Organization, 2011), http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf; World Economic Forum, *The Global Economic Burden of Non-communicable Diseases* (World Economic Forum, September 2011), http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011. pdf.

295 WHO Media centre, 'Tobacco - Fact Sheet 339,' *World Health Organization*, May 2012, http://www.who.int/mediacentre/factsheets/fs339/en/index.html.

296 WHO Media centre, 'Alcohol - Fact Sheet,' *World Health Organization*, February 2011, http://www.who.int/mediacentre/factsheets/fs349/en/index.html.

297 World Health Organization, 'Physical Activity,' *Global Strategy on Diet, Physical Activity and Health*, 2012, http://www.who.int/dietphysicalactivity/pa/en/index.html.

298 WHO Media centre, 'Obesity and Overweight - Fact Sheet N°311,' *World Health Organization*, May 2012, http://www.who.int/mediacentre/factsheets/fs311/en/.

299 'Environment: Many Europeans Still Exposed to Harmful Air Pollutants,' *Europa.eu*, September 24, 2012, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/12/1002&format=HTML&aged=0&language=EN &guiLanguage=en.

300 *Health and the Environment*, Policy Brief (OECD, February 2008), http://www.oecd.org/health/healthpoliciesanddata/40396531.pdf.

301 'Environment: Many Europeans Still Exposed to Harmful Air Pollutants.'

302 World Health Organization, 'WHO | Global Health Observatory Data Repository', 2011, http://apps.who.int/ghodata/?vid=10011#; World Health Organization, *Global status report on noncommunicable diseases 2010* (Geneva, Switzerland: World Health Organization, 2011), http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf.

303 'Global Health Observatory Data Repository,' *World Health Organization*, 2011, http://apps.who.int/ghodata/.

304 Ibid.

305 Ibid.

306 European Commission, 'Percentage of Population Aged 65 and Over,' *Eurostat Data Explorer*, 2010, http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tps00028.

307 European Commission. Directorate-General for Economic and Financial Affairs, *The 2012 Ageing Report: Economic and Budgetary Projections for the 27 EU Member states (2010-2060) - European Commission*, 2012, http://ec.europa.eu/economy_finance/publications/european_economy/2012/2012-ageing-report_en.htm.

HCSS, LANGE VOORHOUT 16, 2514 EE THE HAGUE
T: +31 (0)70-3184840 E: INFO@HCSS.NL
W: STRATEGYANDCHANGE.NL