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**The economic benefits of health and prevention  
in a high-income country:  
the example of Germany**

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## **Abstract**

This paper complements the current health policy debate, which is largely confined to the cost aspects of health systems, by considering explicitly the potential economic benefits of investing in health in general and via – chiefly primary – prevention. While concerns about high and rising health care costs are justified, we see a pressing need to also measure the benefits, ultimately enabling a complete economic assessment of the socially optimal level of resources for health. Despite the use of Germany as our point of reference, our approach and findings likely apply to a wider set of European high-income countries.

Using new and already existing data, we find that in sheer health terms Germany has a lot to gain from more and better illness prevention. Assuming part of this existing burden can be reduced via effective preventive interventions, we find that the resulting economic benefits – expressed in people’s willingness to pay for a reduction in mortality risk – would be substantial. We also gather Germany-specific evidence to suggest that the existing burden of ill health – whether caused by lack of prevention or treatment – negatively impacts a number of important economic outcomes at the individual and macro-economic level. Referring to work carried out in parallel to this project, we find that a number of cost-effective, primary preventive interventions exist to tackle part of the avoidable disease burden. Yet we note a deficit of economic evaluations, in particular in non-clinical interventions – a finding that underlines the role of government in the production of research on specifically non-clinical prevention. In light of the market failures discussed, from an economic perspective the role of government not only consists of research, but also – surprisingly to many – extends to actual interventions to address the health behaviour-related determinants of chronic disease. With the stakes as high and the economic justification for action in place, the case for scaling up preventive efforts in Germany, backed up by solid epidemiological and economic research, is hard to deny.

## **Zusammenfassung**

Die vorliegende Studie ergänzt die gegenwärtige gesundheitspolitische Debatte, die sich vorwiegend auf Kostenaspekte des Gesundheitswesens konzentriert, indem sie den potentiellen ökonomischen Nutzen von Gesundheitsinvestitionen im allgemeinen und (Primär-)Prävention im besonderen hervorhebt. Auch wenn die Sorge um hohe und steigende Kosten des Gesundheitswesens berechtigt ist, bleibt die Notwendigkeit, auch den Nutzen der Gesundheitsausgaben zu erfassen, um somit zu einer ökonomisch vollständigen Einschätzung des sozial optimalen Niveaus der Gesundheitsausgaben zu gelangen. Trotz des Fokus auf Deutschland sind unser Ansatz und die Ergebnisse auch auf andere Mitgliedsländer der EU übertragbar.

Wir zeigen anhand neuer und schon bekannter Daten, dass der Spielraum für Gesundheitsverbesserungen, vorwiegend durch Prävention, in Deutschland erheblich ist. Der ökonomische Nutzen – gemessen an der Zahlungsbereitschaft der Bevölkerung – der durch Reduktion eines Teils dieser Krankheitslast mittels Interventionen erzielt werden kann, ist nach unseren Berechnungen beachtlich. Darüber hinaus zeigen mehrere Studien, wie die aktuell gegebene Krankheitslast, ob durch einen Mangel an Prävention oder Versorgung verursacht, eine Reihe relevanter ökonomischer Größen auf individueller und gesamtwirtschaftlicher Ebene beeinträchtigt.

Wie eine parallel durchgeführte Studie der Autoren ergab, existieren auch eine Reihe kosten-effektiver Interventionen im Bereich der primären Prävention. Dennoch bestehen noch Lücken in der ökonomischen Bewertung insbesondere nicht-klinischer Interventionen – ein Ergebnis, das die Rolle des Staates in der Evaluation dieser Interventionen unterstreicht. Aufgrund von Marktversagen in einigen relevanten Bereichen besteht eine ökonomische Rechtfertigung für staatliches Handeln nicht nur im Bereich der Forschung, sondern – überraschend für manche – auch im Bereich der (Primär-)Prävention der nicht-ansteckenden und mit dem individuellen Gesundheitsverhalten verbundenen Krankheiten. Aufgrund des in diesem Papier dokumentierten hohen gesundheitlichen und ökonomischen Nutzens sowie der ökonomischen Rechtfertigung der Rolle des Staates kann das Argument für eine Verstärkung der Prävention in Deutschland nur schwer bestritten werden.

# CONTENTS

ACKNOWLEDGEMENTS .....	8
ABBREVIATIONS .....	8
EXECUTIVE SUMMARY.....	9
SECTION 1: INTRODUCTION.....	10
<b>SECTION 2: THE SCOPE FOR PREVENTION .....</b>	<b>12</b>
LIFE EXPECTANCY AND HEALTHY LIFE EXPECTANCY .....	13
PREVENTABLE CAUSES OF MORTALITY AND MORBIDITY.....	14
HEALTH BEHAVIOUR-RELATED RISK FACTORS.....	17
<b>SECTION 3: THE ECONOMIC CONSEQUENCES OF ILL HEALTH IN GERMANY .....</b>	<b>20</b>
COST-OF-ILLNESS STUDIES .....	21
MICROECONOMIC IMPACT OF ILL HEALTH .....	23
MACROECONOMIC IMPACT OF ILL HEALTH .....	26
<b>SECTION 4: THE ECONOMICS OF (PRIMARY) PREVENTION .....</b>	<b>26</b>
DOES PREVENTION SAVE MONEY? .....	27
IS PREVENTION GENERALLY CHEAPER THAN CURE? .....	28
IS THERE EVIDENCE OF THE COST-EFFECTIVENESS OF PREVENTION?.....	29
WHAT WOULD THE ECONOMIC BENEFIT OF PREVENTION BE IN GERMANY? .....	30
<b>SECTION 5: THE ROLE OF GOVERNMENT IN THE PREVENTION OF HEALTH BEHAVIOUR-RELATED DISEASES .....</b>	<b>36</b>
EXTERNALITIES: TRADITIONAL AND QUASI-EXTERNAL .....	37
DEPARTURES FROM RATIONALITY .....	39
INSUFFICIENT AND ASYMMETRIC INFORMATION .....	40
TIME-INCONSISTENT PREFERENCES OR ‘INTERNALITIES’ .....	41
<b>SECTION 6: CONCLUSIONS.....</b>	<b>44</b>
<b>REFERENCES.....</b>	<b>46</b>
<b>ANNEXES .....</b>	<b>53</b>
ANNEX 1: BACKGROUND TABLES .....	53
ANNEX 2: TECHNICAL NOTES: WHO ESTIMATES FOR DISEASE BURDEN, EUROPE....	57
ANNEX 3: DERIVATION OF REVEALED PREFERENCES FOR DEMAND OF HEALTH GOODS: CALCULATING THE VALUE OF A STATISTICAL LIFE.....	59



## List of tables

Table 1:	Public expenditure on prevention and public health, in percentage of total public expenditures on health, OECD countries, 2002 .....	11
Table 2:	Life expectancy and healthy life expectancy in the EU-15, 2002.....	13
Table 3:	Top 10 diseases as causes of death, in percentages: in Germany 2002 .....	15
Table 4:	Top 10 diseases as causes of total DALYs, in percentages: Germany, 2002.....	16
Table 5:	Ten most important risk factors in percentage of total deaths and total DALYs in Germany, 2002.....	18
Table 6:	Direct costs by selected ICD-10 disease categories: Germany, 2002.....	21
Table 7:	Direct and indirect costs of obesity and co-morbidities in Germany, 1998, in millions of euros .....	23
Table 8:	Deaths attributable to health behaviour-related risk factors: Germany, 2002.....	32
Table 9:	Economic evaluation of CVD reduction .....	35
Table 10:	Economic evaluation of various reductions in risk factor prevalence .....	35
Table 11:	Cost of smoking caused by a 24-year-old smoker in the US (in US\$).....	39
Table A 1:	Diseases ranked by share of male mortality, all ages, under 70 and under 60: Germany, 2002 .....	53
Table A 2:	Diseases ranked by share of female mortality, all ages, under 70 and under 60: Germany, 2002 .....	53
Table A 3:	Diseases ranked by DALYs for males, all ages, under 70 and under 60, as a percentage of all in the respective age category: Germany, 2002.....	54
Table A 4:	Diseases ranked by DALYs for females for all ages, under 70 and under 60, as a percentage of all in the respective age category: Germany, 2002.....	54
Table A 5:	DALYs caused by various cardiovascular diseases among males: Germany, 2002 .....	55
Table A 6:	DALYs caused by various cardiovascular diseases among females: Germany, 2002.....	55
Table A 7:	Average contribution of the 7 major risk factors to the disease burden in developed countries for 7 major chronic conditions, in percentages .....	55
Table A 8:	CVD health care costs by EU country, 2003 .....	56
Table A 9:	Direct medical costs of Type II diabetes: 8 European countries, 1999.....	56

## List of figures

Figure 1:	Standardised age-specific CVD mortality rates in Germany in percentage of EUR-A, 2002.....	17
Figure 2:	Top 10 risk factors in percentage of total DALYs: Germany and the EU-15, 2002.....	19
Figure A 1:	Lower boundary of the economic value of a one-year increase in life expectancy .....	61
Figure A 2:	Optimal health expenditures.....	66

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## Abbreviations

BMI	Body mass index
COI	Cost of illness
CVD	Cardiovascular disease
DM	Deutsche Mark
DALYs	Disability adjusted life years
EU	European Union
EU-15	EU member states before the 2004 enlargement
GBD	Global Burden of Disease
GDP	Gross domestic product
HALE	Health-adjusted life expectancy
IABS	Institut für Arbeit und Bundesagentur für Arbeits- und Berufsforschung
ICD	International Classification of Diseases
IUHPE	International Union for Health Promotion and Education
IV	Instrumental variables
NIDDM	Non-insulin dependent diabetes mellitus
OECD	Organisation for Economic Co-operation and Development.
p.a.	Per annum or per year
PAF	Population attributable fraction
p.c.	Per capita or per person
SOEP	Socio-Economic Panel
UK	United Kingdom
US	United States
WHO	World Health Organization
YLD	Years lost due to diseases or injuries
YLL	Years of life lost

## Executive summary

The current health policy debate is largely confined to the cost aspects of health systems, neglecting the potential benefits – including the economic benefits – of better health. While concerns about high and rising health care costs are justified, we see a pressing need to also measure the benefits, which would enable a *complete* economic assessment and would support fully informed policy making. Such assessment is elusive, but this paper brings such assessment closer to reality by examining the benefits that could be derived from preventive, as opposed to curative, efforts. While not deprecating curative care, we note that it absorbs most health system resources. Despite the use of Germany as our point of reference, we believe our findings likely apply to a wider set of European countries. Our key points are:

- 1) ***Scope for health improvement:*** Much evidence suggests that Germany has a lot to gain from more and better illness prevention. Premature mortality and morbidity due to cardiovascular disease is significantly above the EU-15 average and far above that of the EU's best-performing countries. In principle, seven preventable behavioural risk factors account for more than 60% of Germany's mortality. Ranked by highest to lowest mortality, they are tobacco consumption, high blood pressure, high cholesterol level, high body mass index (BMI), alcohol consumption, physical inactivity and low fruit and vegetable intake.
- 2) ***Resulting economic benefits:*** Our calculations indicate that the economic welfare loss associated with preventable premature mortality alone is very substantial, as are the equivalent expected benefits from any successful prevention programme. For instance, Germans would be willing to pay more than €200 per capita per year to reduce their cardiovascular disease mortality risk to the EU-15 level. Similarly, their willingness to pay for a 25% reduction in tobacco-related mortality would be €950 per person per year and €370 for the same percentage reduction in high BMI-related mortality. (While these are impressive figures, it is important to be aware of their limitations: They do not tell us *how* the interventions should be financed or by *whom*.)

Other empirical evidence reviewed here documents the various ways in which Germany's burden of ill health affects a number of micro- and macro-economic outcomes, suggesting that economic policymakers have reason to consider health investment as a means to help achieve their economic objectives.

- 3) ***Some preventive interventions are good value for money:*** With such high expected benefits, how far can the existing evidence go to inform us about which preventive interventions to choose, and what value would accrue per euro invested? Based on a systematic review of the empirical evidence on economic evaluations of primary prevention – which focused on cardiovascular disease and was undertaken as a parallel project – we find evidence on the cost-effectiveness of several preventive interventions, a result consistent with similar reviews. At the same time we recognise gaps in the literature that call for more research in order to better inform a full-scale, comprehensive prevention programme.

#### 4) *The role of government: doing what the market doesn't:*

- a. ***Research to evaluate interventions:*** Investment in research constitutes an obvious role for government, given the public good property of the production of evidence on population-based, *non-clinical* preventive interventions. Our parallel work demonstrated the heavy bias in existing economic evaluations on *clinical* preventive interventions, reflecting the interest of ‘the market’ (here: the industry) in proving value for money of their products. Further, a considerable number of preventive interventions that are known to be or are considered as “effective” simply have not undergone cost-effectiveness tests. As public budgets are squeezed, policymakers will face even more pressure to justify their decisions on economic grounds.
- b. ***Prevention of health behaviour-related diseases:*** Who should take the initiative on prevention? We argue that even if governments take a strict economic efficiency perspective, a number of rationales (i.e., market failures) justify an explicit role for government in the prevention of ‘lifestyle’-related ill health. This is a far from foregone conclusion, because at least at first sight many of the potential areas of intervention interfere with individuals’ freedom of choice.

In sum, our results show good reasons to expect substantial benefits from serious prevention efforts in Germany (and most likely in other EU countries). There is also a justification for government to act, where available evidence provides sufficient guidance (such as for tobacco taxation as well as certain school-based and workplace interventions). At the same time, scope remains for more work, chiefly on the cost-effectiveness (or cost-benefit) aspects of non-clinical preventive interventions. Such work would clearly help further inform priority setting as well as contribute to a successful approach to prevention that is informed by solid epidemiological, public health and not least economic evidence. With the stakes as high as demonstrated here, such work would be eminently worthwhile.

## Section 1: Introduction

This paper discusses the economic benefits of health and illness prevention in Germany, a country largely representative of European high income countries. We add to the current health policy debate in at least two ways. First, contemporary discussions on health reform in most high income countries – including Germany – are dominated by an almost exclusive focus on concerns over growing costs, with little attention to the health or economic benefits that might accrue from a given amount of health investment. Second, compared to curative health investment, prevention generally seems to earn but a small share of overall health investment, perhaps in part because of the lack of economic evidence in prevention’s favour.

We build on recent work on the economic consequences of health in the European Union (Suhrcke, McKee, Sauto Arce et al. 2005<sup>1</sup>), which generally argues that even in high-income countries further improvements in health may provide economic benefits. In addition, we build on new evidence produced for this report and on related, parallel work (Schwappach, Boluarte, Suhrcke et al. 2006), a systematic review of the evidence on economic evaluations of primary prevention of cardiovascular disease (CVD).<sup>2</sup>

While the adage “an ounce of prevention is worth a pound of cure” captures the imaginations of policymakers and the public and inspires expectations of huge gains to be reaped from greater investment in prevention, such inspiration fades at the moment of policy-making. In the quest for public and private resources, prevention is challenged in obtaining tangible public and political support (see Table 1). Unlike curative care, prevention has no identifiable beneficiaries and is commonly assailed for immediate costs and delayed benefits. In addition, and this was the reason underlying the Schwappach, Boluarte, Suhrcke et al. review, the economic evidence favouring prevention is often said to be largely missing.<sup>3</sup> With an increased acceptance of the need to use economic evaluations as one input in priority setting, any lack of economic evidence puts prevention at a clear disadvantage.

**Table 1: Public expenditure on prevention and public health, in percentage of total public expenditures on health, OECD countries, 2002**

<i>Country</i>	<i>Percentage</i>
Canada	10.5
USA	8.1
Mexico	5.4
Germany	3.9
Hungary	3.7
Ireland	3.1
Switzerland	2.4
Finland	2.3
Austria	2.3
France	2.1
Spain	1.5
Luxembourg	1.5
Italy	0.7

Source: OECD (2004).

Notes: Data in this table should not be interpreted too literally, as there are persistent difficulties in measuring prevention expenditures.

- 1 For article versions of this report see Suhrcke, McKee, Sauto Arce et al. (2006) or Suhrcke, McKee, Stuckler et al. (2006).
- 2 For the systematic review, we defined “primary prevention” as comprising health promotion addressing smoking, physical activity and dietary intake, screening for risk factors as well as risk factor modification.
- 3 See e.g., Russell (1986) or Canadian Health Services Research Foundation (2003).

To present our assessment of the promise of illness prevention in Germany, we structured this paper as follows. Before engaging in the economic arguments, Section 2 examines whether there is reason to believe that significant health gains can be achieved through preventive interventions in Germany; if Germany is outperforming similar countries in terms of prevention, more investment would be much less warranted. In this section, as well as in the rest of the paper, for brevity's sake we take a very aggregate perspective, at most disaggregating our data by age and gender, leaving the important issue of the socio-economic distribution of (preventable or general) ill health outside.<sup>4</sup> Section 3 reviews the available evidence on the economic consequences of ill health in Germany, distinguishing different (but still relatively narrow) concepts of economic consequences: cost-of-illness and micro- and macro-economic evidence. Taken together, this evidence provides an initial idea of the economic benefits that might be realised by investing in health in Germany, partly via more and better prevention. This evidence by itself may also stimulate *economic* policymakers to consider investing in health as one means by which to achieve their objectives.

Section 4 starts by briefly discussing selected economic aspects of prevention, in particular 1) whether prevention is cost-saving, 2) whether it is (generally) cheaper than cure, and 3) key results of the literature review on economic evaluation of the primary prevention of CVD. Subsequently, the main contribution of Section 4 is our own simplified calculation of a welfare economic (and hence broader) measurement of the likely economic benefits that might derive from different scenarios of more or less 'successful' prevention in Germany. Section 5 discusses the economic rationale for a government role to prevent so-called 'lifestyle-related' diseases. Section 6 summarises the report, noting the promise of health improvement through proven prevention efforts, the areas where further research is most needed and the argument for a government role in both research and illness prevention. It calls for action, where available evidence offers sufficient guidance, as well as research that would help further improve the information base of policy-making and, ultimately, produce greater value for the money invested in health.

## Section 2: The scope for prevention

This section quantifies the scope for improving health through preventive interventions in Germany. If none exists, there would hardly be justification for considering a major scaling-up of prevention. While life expectancy and health life expectancy data show existing, but limited scope for improved health in Germany, there is far more room for improvement when looking at CVD and risk factor indicators.

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<sup>4</sup> For an extensive overview of the evidence on the existing, significant socio-economic differences in the disease burden and risk factor prevalence in Germany, see e.g. Sachverständigenrat (2005). The evidence shows that poor health and poor health habits are disproportionately affecting the socially and economically disadvantaged groups of society. For many health indicators, there is also evidence of a gradient in health across the entire income scale. Taking into account the socio-economic distribution of health would no doubt reinforce the case for prevention, at least from an equity and rights-based perspective.

## *Life expectancy and healthy life expectancy*

Judged by life expectancy at birth – perhaps the most commonly used general population health indicator – Germany assumes a medium rank within the EU-15, at 1.7 years lower life expectancy than top-performing Sweden, but still within the range of what other countries with similar levels of economic development have achieved (Table 2, 3<sup>rd</sup> column). The picture changes somewhat when looking at the gender-disaggregated rankings (not shown here): the German male population is comparatively worse off (9<sup>th</sup> rank) than its female counterpart (7<sup>th</sup> rank).

**Table 2: Life expectancy and healthy life expectancy in the EU-15, 2002**

Rank	Country	Life expectancy	Country	Healthy life expectancy
1	Sweden	80.4	Sweden	73.4
2	Italy	79.7	Italy	72.8
3	France	79.7	Spain	72.6
4	Spain	79.6	France	72.0
5	Austria	79.4	<b>Germany</b>	<b>71.9</b>
6	Luxembourg	78.8	Luxembourg	71.6
7	<b>Germany</b>	<b>78.7</b>	Austria	71.5
8	Netherlands	78.6	Finland	71.2
9	Belgium	78.4	Netherlands	71.2
10	Greece	78.4	Belgium	71.2
11	Finland	78.2	Greece	71.0
12	UK	78.2	UK	70.7
13	Denmark	77.2	Denmark	69.9
14	Ireland	77.1	Ireland	69.8
15	Portugal	77.1	Portugal	69.3
	<i>EU average</i>	<i>78.6</i>	<i>EU average</i>	<i>71.3</i>

Source: WHO Burden of Disease Statistics. Available at [www.who.int/healthinfo/bod/en/](http://www.who.int/healthinfo/bod/en/) (accessed 01/03/2007).

However, life expectancy differs very little among rich countries (compared to the very big differences in life expectancy among low- and middle-income countries), which potentially hides differences in health that nevertheless do exist. Life expectancy is a mortality-based indicator that fails to capture morbidity, nor does it contain information about future health challenges arising, for instance, from current unhealthy behaviour that might have medium- or long-term health consequences.

In hopes of finding scope for health improvement in Germany, we turn to “healthy life expectancy” (HALE<sup>5</sup>). This indicator overcomes some of the limitations embedded in the life expectancy indicator by capturing both mortality and morbidity. It is increasingly used for cross-country comparisons, although actual comparability is sometimes limited. On the basis of HALE, the German population’s health status appears more favourable than that of life expectancy. As Table 2 (last column) indicates, Germany climbs from seventh to fifth rank with HALE as the indicator.

While superficial, Germany’s picture of overall population health – measured by life expectancy and HALE – appears to be very near the average compared to similarly developed countries – close to neither the worst nor best performers. Since both life expectancy and HALE indicate some but not very much scope for future health improvement, we look more closely at what may be hidden underneath these very general population health indicators. Our goal is to determine whether preventive efforts might achieve significant health improvement in more specific areas.

### *Preventable causes of mortality and morbidity*

Neither the life expectancy nor HALE indicator tells us the extent to which any feasible health improvement could be achieved by a preventive as opposed to a curative approach. In this sub-section we look at specific diseases and risk factors for disease and death, in order to explore whether preventive efforts might be particularly well suited for tackling certain challenges. In an attempt to detect potential areas where Germany could be ‘under-performing’, we focus on its ‘biggest’ diseases and risk factors, defined in terms of the share of mortality and morbidity they account for, as follows:

**Cardiovascular diseases** account by far for the greatest share of deaths in Germany: 42% for men and 53% for women (Table 3). Other diseases also matter, as discussed around Table 4.

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5 We have two principal summary measures that seek to capture both mortality and morbidity in a single measure: HALE (used here) and DALYs (used below, e.g., in Table 3). While HALE focuses on expectancies of healthy life, DALYs focuses on years “lost” to death or morbidity. HALE can be seen as the health credit or the number of healthy years people can expect to live under current conditions. DALYs, on the other hand, estimate the healthy time lost to premature death and/or ill health: the equivalent of the healthy years that did not happen, or the health debit (WHO Regional Office for Europe 2005). For a basic description of the Burden of Disease data used in much of this section, see Annex 2.

**Table 3: Top 10 diseases as causes of death, in percentages: in Germany 2002**

Rank	Males		Females	
	Diseases	Total deaths (%)	Diseases	Total deaths (%)
1	Cardiovascular diseases	41.9	Cardiovascular diseases	52.7
2	Malignant neoplasms	30.0	Malignant neoplasms	23.8
3	Digestive diseases	5.7	Digestive diseases	4.6
4	Respiratory diseases	4.8	Respiratory diseases	3.1
5	Neuropsychiatric conditions	3.5	Diabetes mellitus	3.0
6	Unintentional injuries	3.1	Respiratory infections	2.7
7	Respiratory infections	2.4	Neuropsychiatric conditions	2.6
8	Intentional injuries	2.3	Unintentional injuries	2.0
9	Diabetes mellitus	2.0	Infectious and parasitic diseases	1.4
10	Infectious and parasitic diseases	1.5	Genitourinary diseases	1.4

Source: WHO Burden of Disease Statistics. Available at [www.who.int/healthinfo/bod/en/](http://www.who.int/healthinfo/bod/en/) (accessed 01/03/2007).

Notes: See Annex Tables A 1–A 4 for further rankings using different age categories, for both mortality and disability-adjusted life years (DALYs), discussed next.

Table A 1 and Table A 2 in the Annex rank CVDs second in terms of the proportion of premature mortality (defined either as below age 70 or below age 60) for both males and females. The most important disease by this measure is cancer, which accounts for a particularly large share (close to 50%) of premature deaths in women.

The picture changes in a different way when using disability-adjusted life years (DALYs) to look at mortality *and* morbidity together: DALY is a measure that expresses years of life lost to premature death and years lived with a disability of specified severity and duration. CVDs rank second after neuropsychiatric conditions (see Table 4) – a disease category that accounts for a very high share of morbidity. In terms of DALYs below the ages 70 and 60 Tables A 3 and A 4 show that CVDs remain second for males, while they fall to third place for females below age 70 (being overtaken by cancer), and to fourth place for females below 60 (being overtaken by respiratory diseases).

Table 4: Top 10 diseases as causes of total DALYs, in percentages: Germany, 2002

Rank	Males		Females	
	Diseases	Total DALYs (%)	Diseases	Total DALYs (%)
1	Neuropsychiatric conditions	24.3	Neuropsychiatric conditions	28.1
2	Cardiovascular diseases	20.8	Cardiovascular diseases	18.8
3	Malignant neoplasms	17.7	Malignant neoplasms	17.0
4	Digestive diseases	6.1	Sense organ diseases	5.5
5	Unintentional injuries	5.6	Musculoskeletal diseases	5.5
6	Respiratory diseases	5.6	Respiratory diseases	5.2
7	Sense organ diseases	4.5	Digestive diseases	5.0
8	Musculoskeletal diseases	3.3	Unintentional injuries	3.0
9	Intentional injuries	2.9	Diabetes mellitus	2.0
10	Diabetes mellitus	1.9	Infectious and parasitic	1.6

Source: WHO Burden of Disease Statistics. Available at [www.who.int/healthinfo/bod/en/](http://www.who.int/healthinfo/bod/en/) (accessed 01/03/2007).

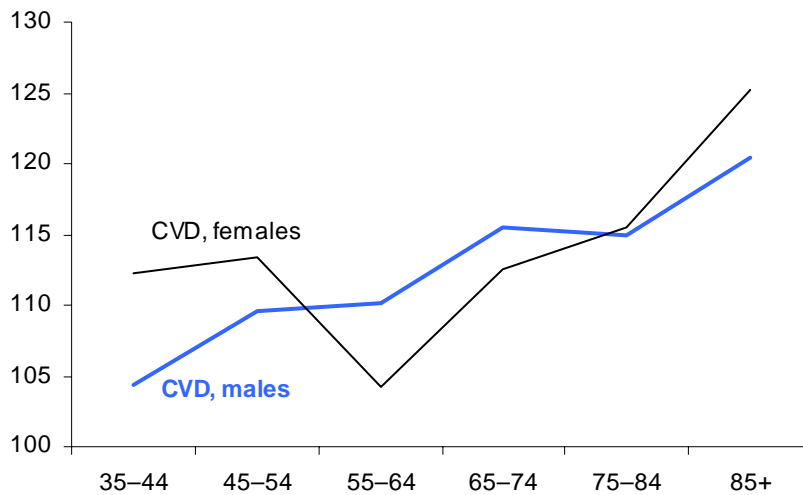
These findings show that CVDs hold scope for significant health improvements in Germany in terms of their sheer size, although it says nothing as to how much of the mortality or disease burden is avoidable through interventions. The question then again arises whether they matter in all European high income countries or whether Germany is characterised by *particularly* high rates of CVD-related mortality and morbidity – further indicating realistic scope for improvement.

Figure 1 shows that Germany's standardised age-specific CVD mortality rates do exceed the average levels in a comparable set of European high income countries (the "EUR-A" category<sup>6</sup>). For instance, for men aged 45–64 the probability of dying from CVD is about 10% higher in Germany than in the EUR-A average. Men aged 65–74 have a 15% higher CVD mortality risk than the European average. Overall, the gap between Germany and the average for EUR-A tends to grow with age for both females and males.<sup>7</sup>

6 EUR-A comprises those countries of the WHO European Region that have very low child and very low adult mortality in a global comparison. WHO uses the letters A through F to classify sub-regions by combinations of child and adult mortality rates. Essentially, European high income and some countries outside the EU-15 are in the EUR-A classification.

7 Annex Tables A 5 and A 6 disaggregate DALYs for different disease categories by gender and age for Germany.

Figure 1: Standardised age-specific CVD mortality rates in Germany in percentage of EUR-A, 2002



Source: WHO Regional Office for Europe (2006), European mortality database (MDB).

These comparatively high CVD mortality rates point to one potential area that could at least in principle be targeted by ‘more’ and ‘better’ prevention. However, improved medical treatment could also improve CVD mortality. There is indeed a debate as to the relative merits of treatment and prevention in explaining past CVD (or overall) mortality reductions in high income countries.<sup>8</sup>

### *Health behaviour-related risk factors*

When trying to assess the potential health benefits from prevention, it is of particular relevance to focus on the mortality and disease burden that is more directly induced by health behaviour-related (and hence preventable) risk factors: smoking, obesity, poor diet, etc. Prevention can and should address health behaviours – the proximate

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8 Studies in the US attributed about a third of the decline in CVD mortality rates to behavioural changes (e.g., improved diet, less tobacco use); a third to medication (e.g., anti-hypertensive, anti-cholesterol drugs, etc.); and a third to intensive technology (e.g., for management of an acute heart attack, etc.). A portion of the behaviour change factor was attributed to individuals who had already survived an acute episode. In all, at least 80% of the decline in mortality is attributed to clinical services (Cutler 2001). Studies in other countries, and using other methods, found mixed results. In still other studies, however, the role of medical care was much less prominent, sometimes less than 50%: See e.g., Tunstall-Pedoe et al. (2000), Laatikainen, Critchley, Vartiainen et al. (2005), and Critchley and Capewell (2002). In sum, these results are highly country-specific, and to the best of our knowledge no such study exists for Germany. However, as our descriptive analysis of the risk factors in Germany indicates on the following pages, the scope for risk factor reduction does indeed seem considerable, so there may be reason to expect the potential future role of prevention to be at the higher end of what studies have found in other countries thus far.

determinants of morbidity and mortality – in one way or another. What are the risk factors that account for the greatest disease burden/mortality in Germany?

Table 5 shows the 10 most important risk factors in Germany – measured by the proportion of deaths and DALYs they account for. These estimates are based on a comparative risk assessment analysis originally made for the World Health Report 2002 (WHO 2002) and updated for European countries for the 2005 European Health Report (WHO Regional Office for Europe 2005) with new data on disease burden and country-specific exposure for the risk factors.<sup>9</sup>

**Table 5: Ten most important risk factors in percentage of total deaths and total DALYs in Germany, 2002**

Rank	Risk factor	% of total deaths	Risk factor	% of total DALYs
1	High blood pressure	18.9	Tobacco	10.8
2	Tobacco	12.4	High blood pressure	7.9
3	High cholesterol	11.6	High BMI	7.1
4	High BMI	8.2	High cholesterol	6.1
5	Physical inactivity	7.1	Alcohol	3.0
6	Low fruit and vegetable intake	3.4	Physical inactivity	2.1
7	Urban outdoor air pollution	2.7	Low fruit and vegetable intake	1.7
8	Unsafe sex	2.3	Illicit drugs	1.6
9	Occupational carcinogens	0.7	Unsafe sex	1.1
10	Illicit drugs	0.4	Iron deficiency	0.8

Source: WHO Burden of Disease Statistics. Available at [www.who.int/healthinfo/bod/en/](http://www.who.int/healthinfo/bod/en/) (accessed 01/03/2007).

Note: BMI is body mass index.

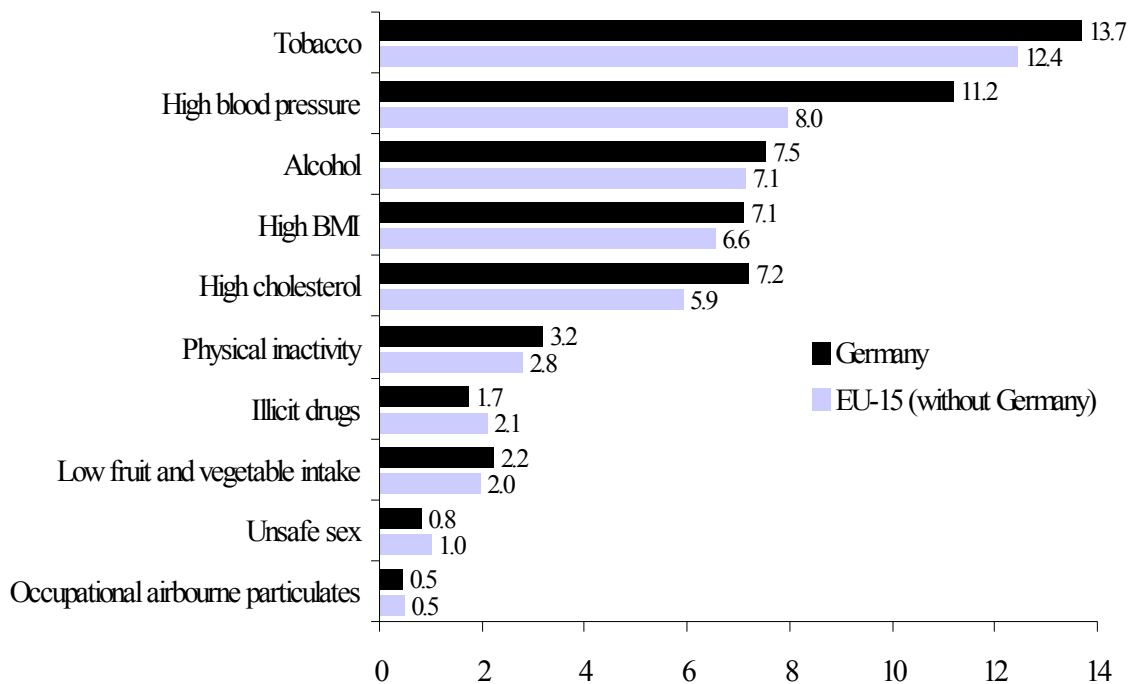
The six most important risk factors in terms of mortality are the key predictors of CVD (and cancer – the other main cause of mortality). Taken together these six risk factors account for 62% of overall mortality and, by contrast, a smaller share of DALYs: 37%. From a prevention perspective – and at very first glance – it is notable that the most important risk factors are at least in principle preventable. Another question is whether the behaviour that underlies or describes these risk factors can (and should) be influenced by policy. However, even if such ‘effective’ interventions exist, from an

9 For most of the risk factors, the basis is either data for the average exposure within the sub-regional country group (EUR-A, -B and -C) or the overall disease-specific population attributable fraction (PAF) for the country group applied at country level. For example, the country-specific exposure to alcohol is based on adjustments of the sub-regional distribution of consumption by applying country-specific estimates of abstainers and the apparent consumption per person. The associated mortality and disease burdens are based on the best available information and will usually have more uncertainty at country level than on regional level and can therefore only be improved by using better country-specific exposure data. See Ezzati, Lopez, Rodgers et al. (2004) for a detailed methodological description.

economic perspective the challenge remains to find effective interventions that are worth their cost – that is, ‘cost-effective’. Cost-effectiveness was the focus of the Schwappach, Boluarte, Suhrcke et al. review, which is summarised in Section 4. The question whether the problems should be addressed by governments, from an economic perspective, is addressed in Section 5.

The above data on risk factors show only that certain factors account for a sizable share of the mortality and disease burden in Germany but not that the share is particularly large compared to any relevant benchmark. If these factors account for a rather low share in Germany compared to other European countries, there is little justification for considering them as priorities for prevention. However, Figure 2 indicates that at least for some important CVD-related risk factors (e.g., tobacco, high blood pressure, high BMI and high cholesterol), the shares out of total DALYs seems particularly high in Germany, assuming the EU-15 average (excluding Germany) is an appropriate guide.

Figure 2: Top 10 risk factors in percentage of total DALYs: Germany and the EU-15, 2002



Source: WHO Burden of Disease Statistics. Available at <http://www.who.int/healthinfo/bod/en/> (accessed 01/03/2007).

Having established that certain diseases (i.e., CVDs) and their attributable risk factors make a sizable contribution to morbidity and mortality in Germany, our next question is: What are the *economic* consequences of ill health in Germany?

## Section 3: The economic consequences of ill health in Germany

This section reviews the available evidence on the economic consequences of ill health – with a focus on chronic disease – in Germany. We focus on prevention in discussing the economic consequences of certain risk factors further below, but the purpose of this section is more general: to show that health is a significant contributor to several important economic indicators, at individual and economy-wide levels. This finding provides a rationale for economic policymakers to consider health investment – curative and preventive – as one means to achieve their primarily economic objectives.

There are, of course, different ways of measuring the economic consequences of ill health, and the boundaries between them are not always clear. For the purpose of the present section, three – comparatively narrow – economic concepts are distinguished (leaving a fourth and broader economic concept to be treated separately in Section 4): the ‘cost-of-illness’ (COI) approach, the microeconomic approach and the macroeconomic approach. COI studies are useful in beginning to illustrate the economic magnitude of chronic disease or its risk factors, accounting for both direct medical expenditures and losses due to forgone productivity. However, there are limitations to the COI approach, as often implemented, rendering it less suitable in assessing the true economic consequences of ill health, so we also rely on the other approaches.

The microeconomic perspective – examining economic consequences at the level of the individual and the household – is another way to approach and analyse these economic consequences. Microeconomic study is promising because it offers reasonable possibilities to address causality, needed by policymakers who must tease out the relationship between cause and effect in targeting determinants of disease and understanding economic indicators. In addition, the relationships microeconomic studies describe often offer more intuitive insight than those relationships observed at the macroeconomic level.

The consequences of ill health can in principle also be analysed at the macroeconomic level. Several studies assess the role of health, most often measured by life expectancy, in determining the level or the growth rate of national income. Yet, as Suhrcke, McKee, Sauto Arce et al. have argued (2005), the extent to which these results can be directly applied to high income countries such as Germany may be limited. (Because life expectancy is comparatively weak in discriminating among the health status levels of rich countries, it may not be surprising that several studies did not find statistically significant growth effects in rich country samples). Research on the role of health in high income countries alone has indeed been limited, but we do present recent findings from related work on the role of CVD mortality in economic growth (Suhrcke and Urban 2006.)<sup>10</sup>

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10 There is also a broader measurement of the macroeconomic effect (employed in Section 4) that involves interpreting, and hence measuring more directly, the contribution of chronic disease-related health loss to social welfare (the utility of people considered in aggregate). See e.g., Nordhaus 2003. Utility gains from better health are considered by some to represent a ‘true’ economic gain, recognising that the purpose of economic activity is to maximise social welfare. See WHO (2005) for an initial application of the approach to the measurement of the welfare loss associated with chronic disease.

## *Cost-of-illness studies*

**Cardiovascular diseases:** Petersen, Peto, Raymer et al. (2005) estimated the direct, indirect and informal care costs associated with CVDs in all EU countries. They estimated the total cost to the EU economy at €169 billion a year, a total annual per capita cost of €3724. Annual per capita costs vary over 10-fold between Member States – from just under €50 in Malta to over €600 in Germany and the UK. Of the total cost of CVD in the EU, around 62% is due to direct health care costs, 21% to productivity losses and 17% to informal care. Table A 8, shows estimates for only the direct cost (i.e., health care costs) of CVDs in all EU countries. Germany has the highest per capita cost, and five of those countries devote a higher percentage of health care expenditure to CVD-related care than Germany.

The Federal Statistical Office for Germany recently published a comprehensive assessment of the health care costs resulting from the treatment of different diseases, totalling €223.6 billion in 2002 (Statistisches Bundesamt 2004). As Table 6 shows, circulatory diseases accounted for the greatest share of those costs.

**Table 6: Direct costs by selected ICD-10 disease categories: Germany, 2002**  
In billions of euros

<i>Disease category</i>	<i>Cost</i>
IX. Diseases of the circulatory system	35.4
XI. Diseases of the digestive system	31.1
XIII. Diseases of the musculoskeletal system	25.2
V. Mental and behavioural disorders	22.4
II. Malignant neoplasms	14.7
IV. Endocrine, nutritional and metabolic diseases	12.9
X. Diseases of the respiratory system	12.3
XIX. Injury and poisoning	10.5
Others	59.0

Source: Statistisches Bundesamt (2004).

**Alcohol-related costs:** Horch and Bergmann (2003) prepared a detailed calculation of alcohol-related costs in Germany in the mid-1990s. They estimated direct and indirect costs to total 40 billion DM in 1995: 1.13% of GDP. Of the indirect costs (24 billion DM), the greatest share was from premature mortality, followed by early retirement and by inability to work. Of direct costs (totalling 15 billion DM), the greatest share was for hospital treatment.

**Smoking-attributable mortality and morbidity:** Welte, Kööand Leidl (2000) analysed the costs of smoking-attributable mortality and morbidity in Germany in 1993,

estimating costs from a societal perspective. Direct costs were mainly calculated based on routine utilization, and expenditure statistics and indirect costs were calculated according to the human capital approach. They found that 22% of all premature male and 5% of all premature female deaths as well as 1.5 million years of potential life lost were attributable to smoking. The total cost came to 33.8 billion DM (€16.9 million), i.e., 20% of total health expenditure<sup>11</sup> and 2% of GDP in 1993. The costs of acute hospital care, in-patient rehabilitation, ambulatory care and prescribed drugs were 9.3 billion DM (€4.6 million), of mortality were 8.2 million DM (€4.2 million) and costs due to work days missed and early retirement were 16.4 billion DM (€8.2 million). Including the productivity loss from missed work substantially increases indirect costs.

**Smoking-related costs:** Ruff, Volmer, Nowak et al. (2000) estimated the economic burden of smoking-related costs for selected diseases associated with smoking in Germany in 1996 to be €16.56 billion (split almost equally between direct and indirect costs). The diseases included chronic obstructive pulmonary disease, lung cancer, stroke, coronary artery disease, cancer of the mouth and larynx, and arteriosclerotic occlusive disease.

**Obesity:** Sander and Bergemann (2003) applied a COI approach to measure the cost of obesity and selected co-morbidities in Germany. They found the total costs to be €2,701–5,682 million per year, including €1,343–2,699 million for direct treatment costs. These magnitudes led the authors to recommend both further research and action at the health policy level.

Their cost estimates were based on data from the German National Survey of 1998. Of the German adult population (25 years and older), 20.3% were estimated to be obese (with obesity defined as a BMI of 30 or greater). To conservatively estimate costs and due to data limitations, only four obesity co-morbidities were included: non-insulin dependent diabetes mellitus (NIDDM), myocardial infarction, hypertension and stroke. To estimate the proportion of disease (e.g., stroke) that is due to obesity (i.e., the ‘exposure’), the authors used odds ratios and relative risks, as frequencies of the disease by exposure status are not known. Odds ratios linking obesity to disease were taken from the literature, where possible from German data. The analysis used a top-down approach, matching health care spending with specific diseases. Costs were separated into indirect and direct costs; the latter included outpatient treatment, medication including over-the-counter drugs, hospitalisation and rehabilitation, as shown in Table 7.

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<sup>11</sup> The share of direct costs in total health expenditures would be 5.6%.

Table 7: Direct and indirect costs of obesity and co-morbidities in Germany, 1998, in millions of euros

	Obesity	NIDDM*	Myocardial infarction	Hypertension	Stroke
<b>DIRECT COSTS</b>	<b>332</b>	<b>1,180</b>	<b>2,053</b>	<b>2,508</b>	<b>1,502</b>
- Outpatient treatment	200	266	431	689	169
- Drugs	1	317	395	1,496	547
- Hospitalisation	69	569	1,109	246	759
- Rehabilitation	62	28	119	77	27
<b>INDIRECT COSTS</b>	<b>328</b>	<b>778</b>	<b>4,710</b>	<b>1,354</b>	<b>1,555</b>
- Due to mortality	67	161	1,656	64	512
- Due to work loss	150	292	1,675	755	355
- Due to disability	112	325	1,890	535	688
<b>TOTAL COSTS</b>	<b>660</b>	<b>1,958</b>	<b>6,763</b>	<b>3,862</b>	<b>3,058</b>

Source: Sander and Bergemann (2003).

\* Non-insulin dependent diabetes mellitus.

**Diabetes Mellitus:** The ‘Cost of Diabetes in Europe – Type II study’ (CODE-2) was the first coordinated attempt to measure total health care costs of Type II (non-insulin dependent) diabetes mellitus in Europe (Jönsson 2002). Based on a 1999 survey, the study evaluated more than 7000 patients with Type-II diabetes in eight countries: Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden and the UK. Total direct medical costs were estimated at €29 billion a year (1999 values) and the average cost per patient €2,834 a year. Of these costs, hospitalisation accounted for most (55% on average). In contrast, drug costs for disease management were relatively low, with anti-diabetic drugs and insulin accounting for only 7% of the total health care costs. Of the eight countries, Germany had the highest average per patient cost in 1999 at €3,576 (see Table A 9).

As noted, COI studies are useful in identifying the importance of a specific condition but suffer a number of limitations (see, e.g., Suhrcke, Nugent, Stuckler et al. 2006 for details). Several of the microeconomic studies cited in the next subsection address some technical challenges involved in determining causality.

### *Microeconomic impact of ill health*

The multi-dimensional economic consequences of ill health are clearly perceived at the microeconomic level, where linkages between dimensions can also be seen. Studies in the German context focus on health’s labour market impact, where, no doubt, data are most readily available. Yet this is not the only channel whereby ill health can affect

economic outcomes. It can also affect an economy by reducing savings and educational attainment. While both have been proven as fairly important in developing countries, very little research has been done in rich countries on the subject (see Suhrcke, McKee, Sauto Arce et al. 2005).

**Labour market participation:** To assess the extent to which illness affects labour market participation, Riphahn (1998) focused on sudden deteriorations of health, 'health shocks'. This approach enabled her to avoid the endogeneity in the relationship between labour market participation and health status. Her analysis is based on pooled data from the first 11 waves of the German Socioeconomic Panel (1984–94) and on a sample of full-time employed West Germans aged 40 to 59 (ending at age 59 since at age 60 individuals might be entitled to retirement benefits). She defined a health shock as a drop of at least five points (on a scale from 0 to 10) in health satisfaction within one year. She found that 13% of those suffering a health shock were no longer fully employed in the next period, compared to 5.3% in the overall sample. The percentage increased to 17.5% two years after the health shock. The impact of a reduction in health was much greater among women, 20.5% of whom left full-time employment after experiencing a health shock. Using a multinomial logit model, she estimated the probability of labour transition after suffering a negative health shock<sup>12</sup> and found that such shock increased the probability of entering part-time employment by about 60%, unemployment by 90% and of leaving the labour force by more than 200%. Moreover, among all the characteristics examined, a health shock was the most important determinant of leaving the labour force. She concluded that an opportunity exists for public policies to retain older workers by appropriate workplace health promotion and rehabilitation programmes.<sup>13</sup>

**Retirement:** Siddiqui (1997) found strong evidence of the influence of health status on the retirement decision by using data from the German Socio-Economic Panel to look at men in West Germany who had reached the minimum retirement age (58 in the German institutional framework).<sup>14</sup> This author analysed retirement behaviour using a model that describes an individual's retirement decision as a trade-off between income from postponing retirement versus leisure from early retirement. The model captures the influence of several explanatory variables, including two measures of health status,<sup>15</sup> on an individual's preference for leisure. The health measures used were the degree of disability based on a physician's assessment of the individual's capacity to fulfil his or her job requirements and a dummy variable indicating whether he or she suffered from a chronic disease (self-assessed). The regression results showed that being disabled or having a chronic disease significantly increased the probability of early retirement. Indeed, the degree of disability seems to be the dominant factor explaining early retirement, with the probability of leaving the labour force at the earliest possible age for disabled men being four times that of men without disability. As Siddiqui noted,

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12 Her method controlled for demographic and human capital measures, characteristics of current employment and labour demand effects.

13 See Bödeker et al. (2002) for a quantification of the costs arising from of work-related disease in Germany.

14 The self-employed were withdrawn from the sample due to their different pension systems.

15 Marital status and educational status are included among the other explanatory variables.

these results suggest that improving or preserving employees' health could be a highly effective measure to raise the age of retirement.<sup>16</sup>

***Obesity and earnings:*** Cawley, Grabka and Lillard (2005) investigated and compared the relationship between obesity and earnings in the US and Germany. Using data from the US Panel Study of Income Dynamics and the German Socio-Economic Panel, instrumental variables (IV) models were estimated that accounted for the endogeneity of body weight. They found that in both countries heavier women tended to earn less. For example, obesity was associated with almost 20% lower earnings for US and German women. The authors also tested for causality using IV models; results suggest that weight may lower labour earnings for US women but yielded no evidence of a causal impact of weight on earnings for women in Germany or for men in either country.

***Probability of being employed:*** Lechner and Vazquez-Alvarez (2004) used the same German data but focused on disability indicators. Their results suggest that becoming disabled can lead to a significantly lower probability of being employed, as much as 9.6% lower. They used data from waves of years 1984 to 2001 for people aged 17–60 years. They divided the 18-wave sample into sequences of observations in three consecutive years for each individual. Individuals were grouped as: 1) a treatment group of individuals who were observed to be non-disabled in the first year of such a sequence and then disabled in the following two years and 2) a control group of individuals observed to be non-disabled during all three (consecutive) years. The authors compared the labour market outcomes of the two groups in the third year of each sequence using two different matching techniques according to each individual's propensity score in the first year of the sequence. (Propensity to becoming disabled was estimated according to a series of characteristics of individuals that might have an effect on their probability of becoming disabled.) Individuals were identified as being disabled if they declared a degree of disability equal to or greater than 30% (although in the sample used, most of the individuals who became disabled had a zero degree of disability in the first year of the sequence). The authors controlled for observable characteristics among both disabled and non-disabled individuals that could have affected their probability of becoming disabled or their probability of employment.

The authors similarly analysed a restricted part of the sample: those who declared to be full-time workers in the first year of each sequence. These individuals might be expected to be better informed about disability policies and the labour market and therefore suffer less than the whole sample in terms of employment upon becoming disabled. However, the study showed that the effect was similar in this more restricted group, where the probability of being out of work was estimated to be 8.5% to 9.2% higher for those who became disabled than for those who did not.

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<sup>16</sup> See also Bödeker et al. (2006) for a more general quantification of the costs of early retirement in Germany

### *Macroeconomic impact of ill health*

Studies that looked at only poor countries or at all countries consistently found that better health, typically measured by life expectancy, is a significant determinant of a country's subsequent economic growth, in some cases contributing more than improved education (see especially Sala-i-Martin, Doppelhofer and Miller [2004]). However, the few studies that looked only at rich countries, where the overwhelming disease burden is from chronic disease, have found no such relationship. Perhaps above a certain level of national wealth, better health no longer contributes to growth, although this conclusion may also be flawed, for two reasons:

First, life expectancy is not a good way to compare health in rich countries because it varies so little. In contrast, death rates from CVD in the working-age population vary substantially among rich countries. We (Suhrcke and Urban [2006]) recently attempted to use this indicator as one (of several) determinants of economic growth in high income countries. In an analysis of 26 rich countries from 1960–2000, CVD mortality in the working-age population emerged as a robust predictor of subsequent economic growth. In one estimate, a reduction of CVD mortality by 10% was associated with an increase in the growth of per capita income by 1 percentage point—small in growth terms, but large in absolute dollar terms when extended over several years. The result was based on a dynamic panel growth regression framework using data in five-year intervals. The model included a set of standard controls (e.g., initial income, government openness, secondary schooling, etc.) and accounted for potential endogeneity problems.

Second, existing analyses fail to account for the scope to raise the official retirement age. A recent simulation exercise showed how an increase in the age of retirement that tracked gains in life expectancy would mitigate many of the adverse economic consequences attributed to societal ageing (Oliveira Martins, Gonand, Antolin et al. 2005).

More work is clearly required to better understand the growth impact of cardiovascular – and more generally, chronic – disease in high income countries such as Germany. It is also important to acknowledge that any attempt to empirically disentangle the determinants of economic growth at the macro level quickly runs up to econometric limitations (Pritchett 2006).

## **Section 4:**

### **The economics of (primary) prevention**

As mentioned, people hold a rather wide range of seemingly contradictory views about the health and economic benefits to be expected from prevention. For brevity's sake, we engage in only brief discussions of two questions and a slightly longer one for a third: (1) Does prevention save money? (2) Is prevention generally cheaper than the cure? and (3) Is there evidence of cost-effective prevention, and, if so, what kind of evidence? After discussing these issues, we propose in the fourth sub-section our own simplified estimates of what the economic benefits of prevention might be in Germany.

## *Does prevention save money?*

Some advocate prevention not only to improve health but also to save money (Fries, Koop, Beadle et al. 1993). Specific hopes have been associated with the improvement of health among the elderly (mainly as a result of prevention) to help significantly relieve the budgetary pressures resulting from ageing societies,<sup>17</sup> particularly if a ‘compression of morbidity’ scenario can be achieved (Fries, Koop, Sokolov et al. 1998). Others dismiss prevention at least in the form of promoting healthy behaviour as ‘a waste of time and money’ (Harvey 1998) or as ‘good medicine, but not good economics’ (Cadmus 1994).

On one hand it is certainly true that a healthier population displays a reduced need for health services, and inferring that a healthier population will spend less on health may be highly intuitive. As Fries, Koop, Beadle et al. (1993, p. 321) note:

Preventing chronic illness would offer hope of a reduction in demand: if a coronary-artery bypass graft procedure costs \$50,000, then avoiding that procedure could save up to \$50,000, depending on the cost of the intervention, on whether the procedure is postponed or prevented, and other offsetting factors.

If those optimistic prospects hold true, prevention also becomes a very attractive alternative to more classical health care cost-control programmes: managed competition, global budgets, rationing, etc. (Russel 1993). Fries et al. (1998), who focussed on the US context, explicitly proposed the wider use of prevention, broadly defined, as a means to control the growth of medical care expenditures – in addition to improving the population’s health. If their conclusions are true, such prospects would surely be very appealing to many European finance ministers.

On the other hand, though, while the idea that prevention should save money may be attractive, supportive evidence remains mixed at best. The US offers some evidence about the health care expenditures that would be averted if its very high obesity rates could be markedly reduced (Lakdawalla, Goldman and Shang 2005), as well as some evidence on the expected benefits of elderly disease prevention – overwhelmingly resulting from hypothetical, successful obesity prevention (Goldman, Cutler, Shang et al. 2006). However, several other studies are far more cautious about the extent to which better health of the elderly could mitigate health expenditure pressures, at least in the US context (Chernew, Goldman, Pan et al. 2005; Joyce, Keeler, Shang et al. 2005).<sup>18</sup> (To the best of our knowledge, similar studies on Germany or any comparable European country are not yet available.) Clearly, then, the prevention optimists’

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17 We do not enter the debate about what the main drivers of health expenditures are, except to say that the ageing process per se is unlikely to account for a major share of future health expenditure increases. Many studies conclude that by far the dominant factor will be technological progress (see e.g., Dormont, Grignon & Huber 2006). If so, there is even more reason to develop more modest predictions about the extent to which prevention (or more generally, better elderly health) can alleviate predicted increases in health expenditure.

18 The main reason why these studies find high health care costs for obesity (and hence large benefits from reducing its prevalence) is that people suffering from the condition incur high health care costs that – unlike for several other health behaviour-related risk factors (e.g., smoking) – are not as highly ‘compensated’ by the expenditure-reducing effect of a lower life expectancy. To avoid misinterpretation, please note that the fact that mortality affects the cash flow of health insurance programmes is purely a factual matter, not a moral one. It has nothing to do with the economic value of life, which is a different, and from a societal perspective far more relevant, figure.

underlying assumption of ‘less health care need = less spending on health care’ is too simplistic, since health expenditures are not determined solely by need.

Whether or not (some) prevention is cost-saving, it is above all not the appropriate economic question if the goal is to achieve the best allocation of a given amount of resources – which is what economics is about. Some preventive interventions may save money while others – probably most – do not. Yet this does not mean that those interventions that do not save money would not be worth implementing, for they could still be net welfare-enhancing from a societal perspective if they allow ‘buying’ the health improvement at a ‘reasonable’ cost. Whether a given intervention achieves a health gain at ‘reasonable’ cost is typically assessed with cost-effectiveness studies (or alternative techniques such as cost-benefit analysis).

The primary purpose of prevention is to improve the quantity and quality of life, and if it does so at a lower cost than other interventions, prevention expenditure is a perfectly rational use of the money from an economic perspective. Furthermore, prevention should not be held to a higher standard than medical care, where cost-saving is commonly not the prime objective. Any type of health intervention – prevention, treatment or rehabilitation – should ideally be evaluated by the same criteria, for instance, cost-effectiveness.

### *Is prevention generally cheaper than cure?*

If cost-effectiveness is the ‘right’ criterion, is prevention universally more cost-effective than cure, as the ‘ounce of prevention’ adage suggests? The answer has to be ‘No’. There is no general law making prevention *always* cheaper than cure, as a simple calculation (Kenkel 2000) illustrates:

Prevention is typically targeted at a larger group than treatment. Only part of this larger group would develop the disease and would then be treated. Assume a given prevention measure targets a group of  $N$  individuals at a cost of  $€P$  per individual and succeeds in completely preventing a specific disease (of course, for certain diseases, this would be impossible). Then, the total cost of prevention would be  $N * P$ . If the incidence rate is  $i$  (number of people contracting the disease divided by  $N$ ), and the curative cost equals  $C$ , then the total treatment cost equals  $i * N * C$ . For the same result, prevention would be cheaper than cure if  $P < iC$ , or  $P/C < i$ . Since  $i$  can be a very small number, at least in this very simplified setup, it will not be easy for prevention to be cheaper than cure. Prevention tends to be cheaper with greater illness prevalence in a population (increasing  $i$ ), with higher ‘economies of scale’ for prevention (if  $P$  is increasing in  $N$ ) and with more expensive medical treatment (increasing  $C$ ).

It follows that some preventive interventions will be cheaper than cure but not others, raising the question, Which *are* cost-effective? In a parallel project we (Schwappach, Boluarte, Suhrcke et al. 2006) performed a systematic literature review on the cost-effectiveness of CVD prevention, summarised next.

## *Is there evidence of the cost-effectiveness of prevention?*

The Schwappach and colleagues analysis reviewed journal articles published in 1995–2005. We used a comprehensive keyword-based search of generic and specialised electronic databases and conducted manual searches of expert databases of cost-utility analyses and German health economic evaluations. The search strategy consisted of combinations of freetext and keywords related to economic evaluation, CVDs and primary prevention interventions for risk assessment or modification: 195 studies met all the relevant inclusion criteria.

Our analysis had two phases. In the first, we evaluated all 195 articles in terms of various key parameters, which allowed us to illustrate and quantify the published evidence, to describe interventions and preventive strategies that had been appropriately evaluated, and finally to draw conclusions on areas that have thus far been outside researchers' focus. In the second phase, we examined a subsample of 35 studies to closely examine economic evaluations of interventions targeted at specific CVD risk factors: dietary intake, weight management and physical activity. This part of our study sought to depict in more detail the available cost-effectiveness evidence on the entire continuum of public health policy – from health promotion to clinical prevention.

On the positive side, we found a significant body of relevant economic evidence favouring CVD prevention, which is in line with other broadly comparable reviews of the economic evaluation of prevention. Reporting on the Canadian perspective of prevention, Goldsmith, Hutchison and Hurley (2004) noted that all eight of the interventions they reviewed produced a net benefit to society, and two even identified cost-savings potential from the payer's perspective. Similarly, the US Centers for Disease Control and Prevention state in the second edition of a report entitled, 'An ounce of prevention ... What are the returns?' that, for example, some childhood vaccines save up to \$29 in direct medical costs for each dollar spent (CDC 1999). Other strategies, such as yearly mammograms, carry a net cost but are considered cost-effective because they give considerable value (in terms of years of life saved) in return for the money invested.

Our review found a relative lack of broader health promotion evidence, especially compared to clinical interventions. However, this does not mean that no economic evidence in favour of broader population-based interventions exists, if we take the reviewed studies literally. One relatively strong area of evidence relates to tobacco consumption, in particular to smoking cessation and taxation, issues addressed in depth elsewhere (Ye, Lee and Chen 2006; van Baal, Brouwer, Hoogenveen et al. 2006). To cite but two studies from our systematic review, Wang, Crosset, Lowry et al. (2001) demonstrated that a project to prevent tobacco use among school children proved cost-saving. This is one of very few studies explicitly targeting adolescents. In another major study, Murray, Lauer, Hutubessy et al. (2003) note that the most cost-effective combination of interventions is a combination of laws to decrease salt content in processed foods and appropriate labelling; health education through broadcast and print media focusing on BMI and cholesterol concentrations; and treating people with an estimated combined risk of a cardiovascular event over the next decade above a threshold of 35% for multiple risk factors (with statin, diuretic,  $\beta$  blocker and aspirin) whatever the values for individual risk factors are.

The main gaps or limitations in the reviewed studies, and of the review method per se, were:

- Few studies assessed broader health promotion interventions targeted at obesity, physical inactivity or dietary intake in children or young adults.
- Rarely have interventions targeting children or young people been evaluated in economic terms, despite the high expected benefits generally attributed to ‘early’ prevention.
- The marked differences in the methodologies and definitions applied among studies severely limits comparability of results.
- Publication bias results in the overrepresentation of studies that report results favouring interventions. Such bias is well documented for the biomedical literature and has been identified as a major threat to reliable syntheses of outcomes research in general and health economic evaluation in particular. Since we could identify, review and summarise only information that *has been published*, we lack information on *what has not been published*.

In terms of further work to better inform policymaking in the area of CVD prevention, our three main conclusions/recommendations are as follows:

- 1) The relative lack of economic evaluations of broader health promotion interventions compared to clinical prevention is regrettable when essentially all industrialised countries are grappling with the mounting challenge of obesity (and other ‘lifestyle-related’ diseases). We remain doubtful that clinical intervention will be the most effective (or even cost-effective) way to tackle challenges of this kind.
- 2) Government has a clear role to engage in the economic evaluation of prevention by filling the information gap left by private industry, first in terms of the evaluation of broader public health interventions and health promotion and second, in clinical prevention, in light of the documented relationship between study funding and the reporting of favourable results.
- 3) Certain methodological features in the way health economic evaluations are currently practised might bias the choice between prevention and cure toward the latter. The Schwappach and colleagues review discusses in particular the issue of the treatment of future costs and even more so the discounting of future health benefits. More work is needed to improve our understanding of how people value future health benefits compared to future monetary costs. In the meantime, it would be recommendable to include scenarios of differential discounting in the sensitivity analysis of economic evaluations. This step would help measure the extent to which people’s valuations of health benefits versus monetary costs affect the results.

### *What would the economic benefit of prevention be in Germany?*

The previous sub-section synthesised the key points drawn from the systematic literature review and related studies. While evidence indicates that a number of interventions to prevent CVD appear to be ‘worth it’ (judged for instance by standard cost-effectiveness criteria), gaps in the evidence remain. The set of preventive

interventions that are known to be effective exceeds that of interventions that have undergone economic evaluations. Given the limited economic evidence, we cannot provide a quantitative assessment of the expected costs and benefits associated with a concrete, comprehensive prevention programme in Germany. We can, however, approach the issue from a different angle by considering the *monetary value society would attribute to a prevention programme that reduced premature mortality (and the disease burden) by a plausible extent*. It is important to note that from a theoretical perspective this is the only ‘true’ economic approach to valuing health, as it represents the natural extension of the methodology of welfare economics to the area of health: Just as for any other consumer good, the value of an improvement in health is the amount society is willing to pay for that improvement. Hence, while the approaches used by the studies summarised in Section 3 also cover important economic effects of health, they assume a too partial view.<sup>19</sup>

The calculations below indicate that the value attributed to such a hypothetical programme would be quite significant. While this result says nothing about *who* should pay and *how*, it does illustrate that a ‘good’ prevention programme would be worth considerable effort and money. It will be the task of future work (informed by more research and evidence) to determine more precisely the prevention package to implement, based on its costs, expected benefits and other criteria that might influence priority setting in the given social and political context.

How do we derive the value that a ‘good’ prevention programme might represent to citizens? The procedure we followed comprised three steps. The first was to establish plausible targets for such a prevention programme, defined in terms of (premature) mortality reduction. The second step was quantifying the value that Germans assign to mortality risk reduction. The last step combined those two steps to arrive at the value Germans would assign to a prevention programme that delivers the mortality reduction target. The exercise is deliberately kept simple and is intended to produce conservative estimates. (For instance, we don’t estimate a value for the potentially significant morbidity reductions that would result.) Our conservative approach ensures that the ‘actual’ benefits would most likely be higher.

Each step can be described as follows in the context of Germany:

### **Step 1:**

***Define plausible mortality reduction targets from a prevention programme:*** We take a very simple, but realistic approach to assess what is feasible in terms of future health improvement, using two complementary approaches – one based on mortality rates due to CVD and the other using unique data on mortality attributable to the most important health behaviour-related factors.

***Reducing cardiovascular disease mortality rates:*** What would a realistic target be for Germany in terms of reducing premature CVD mortality through preventive efforts? We showed in Section 2 that Germany lags behind the EU-15 average in terms of CVD mortality, so a certainly not overly ambitious goal might be to reach recent EU-15 average CVD mortality rates. Data for 2002 (the most recent year for which data are

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<sup>19</sup> See, e.g., Tolley, Kenkel and Fabian (1994) for a more elaborate discussion. The welfare economic approach to valuing health is commonly traced back to Schelling (1984) and Mishan (1971).

available for a larger set of European countries) show a standardised death rate due to CVD in the 0–64 age group in Germany of 47.72 per 100,000 population, compared to 41.13 for the EU-15 average (excluding Germany, of course, and Denmark for which no data were available). A second, far more ambitious goal would be the EU-15’s best performer in 2002: France, with a CVD death rate (age 0–64) of 30.49.

While it is fairly uncontroversial to assume that Germany *could* reach the EU-15 average or the French benchmark, it is far more difficult to say to what extent the gap could be closed by *prevention* (as opposed to curative approaches). Our response is pragmatic: It assumes three scenarios for each of the two benchmarks, whereby 100%, 50% or 25% of the gap would be closed by prevention. While the first scenario is clearly the upper-bound estimate<sup>20</sup> and the third reflects the lower bound, the second scenario implicitly makes use of the finding by Critchley and Capewell (2002), which found that 50% of past CVD mortality reduction in the UK, etc., could be attributed to preventive efforts.

***Reducing premature mortality attributable to the most important risk factors:*** An alternative procedure is to consider a potential reduction in mortality rates directly attributable to the most important health behaviour-related risk factors (Table 8). At least in principle, the deaths attributable to those factors are directly avoidable by prevention. If, for instance, nobody consumed tobacco, tobacco-related mortality would converge towards zero over time. Zero consumption is, however, clearly unrealistic, so the challenge becomes determining the extent to which prevention could reduce the respective risk factor prevalence. Again, we take a pragmatic approach by assuming three reduction scenarios: 100%, 50% and 25%. Of course, we can only consider and evaluate the value of the risk factor prevalence reduction for each risk factor separately. Due to the complex inter-relationship between risk factors (e.g., high BMI and physical inactivity), it would not be appropriate to add the reduced mortality rates for all risk factors taken together.<sup>21</sup> As such, the numbers resulting from the risk factor-based scenarios complement the CVD-based ones above.

**Table 8: Deaths attributable to health behaviour-related risk factors: Germany, 2002**

Risk factor	Attributable deaths
Tobacco	61,548
High blood pressure	39,780
High cholesterol	29,124
High BMI	25,556
Alcohol	16,845
Physical inactivity	13,749
Low fruit and vegetable intake	10,603

Source: WHO Burden of Disease Statistics. Available at [www.who.int/healthinfo/bod/en/](http://www.who.int/healthinfo/bod/en/) (accessed 01/03/2007).

20 The upper-bound estimate might be justified if Germany lags substantially behind in its CVD prevention policies compared to the other EU countries. While some of the outcome indicators suggest that this might be so, it is generally very hard to comparatively and unambiguously assess the quantity and quality of a country’s prevention policies at large.

21 If all risk factor prevalence could be reduced to zero, the reduction in mortality rates would be less than the sum of the reduction for each risk factor separately. More research would be needed to assess the expected health benefit of a reduction in the prevalence of a set of risk factors taken together.

## **Step 2:**

**Develop a quantitative concept of the value Germans assign to mortality risk reduction:** Putting a monetary value on life is highly controversial (among non-economists at least). ‘Health is priceless’ is a second oft-quoted adage. We no doubt are willing to invest a great deal in our health – spending money on doctors, devoting time and effort to exercise, forgoing our favourite unhealthy food. Yet, with limited budget and competing objectives, we cannot and do not spend *all* our resources on health. The same applies at a societal level: Because resources are limited and have more than one potential use, prioritising such use – actually, selecting some uses while discarding others – is necessary. A systematic way of prioritising would be to focus on the policy measures that provide the greatest value for the money. Any decision in this context means placing an implicit (finite) monetary value on health benefits. Decision-making would be easier, more transparent and consistent with a monetary estimate of the value of health benefits.

Much of the reservation about putting a monetary value on life and health stems from a misunderstanding of what such a value actually means. In fact, we cannot – and do not seek to – place a monetary value on our own or others’ lives. Instead, we are valuing (comparatively small) changes in the *risk* of mortality, a very different matter. While under normal circumstances no one would trade his or her life for money, most people would weigh safety against cost in choosing safety equipment, safety against time in crossing a street, and on-the-job risks against different wages. In making these choices, people are implicitly putting a price on their mortality risk.

While the value of mortality risk is not directly observable, it can be inferred from the decisions people make when choosing between mortality risk and financial compensation. The most common procedure uses labour market data about the wage premium workers demand from a job with higher mortality risk. Such a risk premium is typically seen in wage estimations on employee data. For Germany, the current state of research is an estimate by Schaffner and Spengler (2005), using data of the Institut für Arbeitsmarkt und Berufsforschung and the German Socio-Economic Panel. The mortality risk premium is estimated to be 10% in the benchmark regression for the risk of dying at work during a year with a probability of 1 out of 10,000. In other words, workers who face an increased risk of death on a job such that 1 out of 10,000 dies in this job during a year demand a 10% wage increase. The average life risk premium is then €303 per year in 2001 prices for the risk of dying with the probability 1/10,000 during the course of a year, which in turn gives a value of a statistical life of €3.03 million (Annex 3 has the underlying theoretical derivation).

The demand in wages for an increase in mortality risk should equal an individual’s willingness to pay for an equivalent risk reduction (and should therefore express its value). Hence, the estimates of the mortality risk wage premium are at the same time an indicator of what society is prepared to pay for a reduction of mortality risk through the ‘purchase’ of health goods and services.

To drastically simplify the calculation, we assume the probability of dying is constant.<sup>22</sup> Then the probability of dying is reciprocal to the expectancy of future life years. For

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<sup>22</sup> This corresponds to a so called Poisson process of the probability of dying. Of course, a Poisson process does not completely capture the demographic data. One objection is that the expectancy of future life years at birth is identical to this expectancy of a 40-year-old. Yet, it is a widely used assumption (e.g., Nordhaus 2003). As long as we restrict our analysis to a representative individual of

example, a probability of dying per year of 0.0125 corresponds to a life expectancy at birth of 80 years ( $=1/0.0125$ ), sufficiently close for our purposes to the actual German average life expectancy of 78 years. A reduction of life risk by 1.5/10,000 would thus increase life expectancy at birth by about a year.

A representative German would thus be willing to pay approximately €500 per year (in 2006 prices) for a one-year increase in life expectancy. (The above-derived €3.03 million  $\cdot$  1.078  $\cdot$  1.5/10,000 = €490 = approximately €500.)<sup>23</sup> This value can be regarded as the demand price for health goods and services, and it can be used in the third step to evaluate the benefits associated with the mortality reduction scenarios proposed in Step 1.

We point out in the Annex 3 which assumptions are made in this approach and what the range is of estimates for alternative assumptions. Despite the numerous simplifications, our calculated number of the demand price for an increase in life expectancy by one year is amazingly close to the actual health expenditure change during the estimation period 1985–95. Hence, we can apply this price to the following policy experiment with great confidence.

### **Step 3:**

***Combine plausible targets with the value Germans assign to reduced mortality risk to estimate the monetary benefits prevention would provide:*** To calculate the value of the mortality reduction possibly resulting from a successful prevention programme in Germany, we convert the mortality reduction target into an equivalent life expectancy increase. Given the simplifying assumptions made earlier, this is straightforward.

Reducing CVD death rates to the EU-15 level would increase life expectancy by 0.424 years, which – multiplied by €500 – gives a monetary benefit of €212 when expressed in per capita terms. Achieving the significantly lower French benchmark would add 1.118 years to life expectancy in Germany, resulting in a per capita benefit of €559. The economic values of the other two scenarios (50% and 25% reductions to the gap between Germany and the benchmarks through prevention) are in Table 9. The estimates show that even a comparatively small reduction in mortality rates would be worth a significant amount of money to Germans in per capita terms per year.

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the economy, our results remain quite close to calculations that drop this assumption (see Murphy and Topel 2005).

23 By including the 1.078 factor in this formula, we adjust the price the representative German is willing to pay for an additional year of life expectancy at birth by a 7.8% consumer price rise for Germany between 2001 and 2006, assuming health preferences to be homothetic.

**Table 9: Economic evaluation of CVD reduction**

	CVD standardised death rates (0–64), 2002	WTP p.c. and p.a. for immediate and permanent death rate reduction to benchmark value	WTP p.c. and p.a. in case of 50% reduction in gap	WTP p.c. and p.a. in case of 25% reduction in gap
Germany:	47.72			
<i>Two benchmarks:</i>				
EU-15	41.13	€212	€106	€53
France (best performer)	30.49	€559	€280	€140

Note: The EU-15 unweighted average excludes Denmark, for which no data were available for the year 2002, and Germany. WTP is willingness to pay; p.c. is per capita; p.a. is per annum or per year.

Essentially the same methodology can be applied to a second approach that considers different scenarios of reductions in risk factor-related mortality. Table 10 presents results for each risk factor by three scenarios. The gains in life expectancy from a complete elimination of the risk factor prevalence (Column 3) illustrate the enormous size of the current health loss associated with each risk factor. Not surprisingly, converting these potential health gains to a monetary figure produces a very sizable value. As mentioned above, however, it is entirely unrealistic (and may even be undesirable from a welfare economic perspective) that a prevention programme would eliminate 100% of the risk factor prevalence. However, in the much more conservative 25% reduction scenario, the economic value derived from such health gains would be very significant, ranging from €950 for tobacco consumption to €152 for low fruit and vegetable intake.

**Table 10: Economic evaluation of various reductions in risk factor prevalence**

Column	Deaths attributed to risk factor, 2002	Risk factor attributable mortality rate*	Gain in life expectancy by 100% elimination of risk factor	Economic value		
				Elimination scenario	50% reduction scenario	25% reduction scenario
1	2	3	4	5	6	
Tobacco	61,548	0.01142	7.598	€3,799	€1,900	€950
High blood pressure	39,780	0.01180	4.751	€2,376	€1,188	€594
High cholesterol	29,124	0.01199	3.424	€1,712	€856	€428
High BMI	25,556	0.01205	2.989	€1,494	€747	€374
Alcohol	16,845	0.01220	1.945	€973	€486	€243
Physical inactivity	13,749	0.01226	1.581	€790	€395	€198
Low fruit/ veg. intake	10,603	0.01231	1.214	€607	€303	€152

\* The mortality rate due to the respective risk factors is obtained by dividing the total attributable deaths by the population in the age group 30–69, which was approximately 56.7 million in 2001, according to the WHO Mortality Database ([www.who.int/whosis/mort/en/index.html](http://www.who.int/whosis/mort/en/index.html)).

It bears emphasising that it is problematic to directly compare the results of the risk factor-based analysis to that of the CVD-based results. The effect of reductions in some of the risk factor prevalence on mortality rates can affect mortality rates due to causes other than CVD, too, which in part explains why the resulting life mortality reduction effect can be very sizable. (The effect of the main risk factors on the main chronic disease conditions is illustrated in Table A 7). Despite these reservations, the results in Table 10 are impressive.

In sum, the expected benefits, calculated in an admittedly simplified manner (that is, however, very comparable to what many other studies of this kind have undertaken), further underline the potentially large value of successful prevention. We have also seen in this section that there is some evidence of cost-effective interventions, although this area has been comparatively under-researched thus far. If cost-effective programmes can be identified and if the expected benefits are indeed of the order of magnitude shown above, the question arises, Would it be appropriate for governments to take the initiative on prevention – even in areas that concern people’s health-related behaviour?

## Section 5: The role of government in the prevention of health behaviour-related diseases

From an economic perspective, public policy intervention is justified if two conditions are met: A market failure exists, and interventions are available that correct the failure without imposing costs on society that exceed the benefits. This chapter examines if and when the first condition applies in the case of risk factors attributable to chronic diseases: smoking, alcohol consumption and obesity. Given the magnitude of the health and economic burden of lifestyle-related disease, is there a justification – from a liberal economic perspective founded on consumer sovereignty – for public policies to prevent disease?

A rationale for intervention based on the economic perspective differs markedly from a public health rationale, and while there is reason to believe that such an economic rationale exists, it is, of necessity, more nuanced. The public health rationale considers government intervention to be justified whenever the health of the population can be improved. An economic rationale, by contrast, sees health as only one of several objectives within the overall goal of maximising ‘utility’ and typically has severe reservations about any government interference, except for the (probably rather few) cases where governments can do better than markets.

In principle, the economic rationale for intervention can be formulated on both efficiency and equity grounds. It is justified when private markets fail to function efficiently or when the social objectives of equity in access or outcomes are unlikely to be attained. Economists define efficiency very specifically: An allocation of resources is efficient if there is no way to increase benefits to an individual without making someone else worse off (‘Pareto efficiency’). We focus here on the efficiency-based rationale, as it is less normative than the equity argument and space is limited.<sup>24</sup>

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24 This is not to imply that there is no scope for the equity rationale to apply to chronic diseases. Given the evidence on the negative economic effects of chronic disease (presented in Section 3), coupled with the observation that the predominant share of the burden of disease is carried by the poor (see

It is far from obvious that economics would justify government interference in the private sphere of the individual, especially since most of the costs of disease are borne by that individual (i.e., they are private, or ‘internal’, costs). Potential justification for government intervention to correct the failure (and thereby improve social welfare) does exist, however, where the market fails to achieve socially optimal outcomes on its own. Four potential market failures are linked to the chronic disease risk factors: externalities, non-rational behaviour, insufficient and asymmetric information and time-inconsistent preferences that cause serious self-control problems. More extensive treatment of market failures is in Suhrcke, Nugent, Stuckler et al. (2006).

### *Externalities: Traditional and quasi-external*

As discussed here, internal and external costs combined make up the total or ‘social’ costs associated with a disease or a risk factor. Most – by far – of the costs associated with health behaviour-related choices leading to ill health are paid by the consumer: internal costs. Situations do arise, however, when a consumer does not bear all the costs associated with such choice. Then, some of the costs are borne by others or by society at large: external costs or ‘externalities’. (External benefits also exist.) Individuals do not automatically factor externalities into their consumption choices. Individual levels of consumption (e.g., of tobacco, alcohol or unhealthy foods) can be higher or lower than is beneficial to society. The market failure here manifests as a societal cost incurred by an individual choice, and it justifies – in principle – a public policy intervention seeking to improve social welfare by reducing the costs borne by the affected society.

External costs begin where internal costs end and comprise all those costs that are not borne by the decision-maker. Drawing the line between internal and external consequences is of critical public policy relevance. As mentioned, internal costs are the ‘private’ costs borne by the individual, knowingly or not, and are generally irrelevant to an argument for government intervention within the efficiency rationale. The most obvious internal costs associated with a disease resulting from unhealthy behaviour are the individual’s morbidity and mortality costs, easily the greatest share of disease costs if converted into monetary values (using, for instance, the concept of the value of a statistical life, as discussed in Section 4 and Annex 3).

Traditionally, costs borne by all members of a household were considered ‘internal’ (for example, the health consequences to children of smoking by parents were considered internal, even though the children themselves were not participating in the decision or the behaviour). This conceptualisation may be changing to view each household member separately. Costs or benefits borne by household members who are not participating in the choice are called ‘quasi-externalities’ and may justify intervention since they tend to be larger than the external costs borne by the larger society.

***Classical externalities from collectively financed programmes:*** ‘Classical’ externalities are derived from collectively financed programmes, such as health, disability and life insurance; pensions; and sick leave. These programmes are financed by taxes and premiums that do not differentiate between people who engage in unhealthy behaviour

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Sachverständigenrat Gesundheit 2005), the equity rationale may well be relevant for chronic disease intervention in Germany.

and those who do not. From a broad, societal perspective some of these programmes tend to incur external costs and others external benefits, so the issue of whether smokers, heavy drinkers or those engaging in other poor health habits ‘pay their way’ becomes an empirical question. Other things being equal, individuals engaging in unhealthy behaviours doubtless incur higher health care expenditures than those who do not. Because those individuals tend not to pay higher premiums for health insurance which would reflect their higher health care costs, many costs generated by their unhealthy behaviours are borne by the other contributors to the insurance.

However, people with poor health habits tend to die younger, reducing the number of years they require financial support from collectively financed programmes. Several studies have shown this effect of early death to be potentially large: It can outweigh the external costs represented by increased health insurance costs, and it can outweigh the loss of tax and premium payments (which finance many of these programmes). Contrary to popular belief, on a net financial basis society does not always ‘subsidise’ people with poor health habits.

Indeed, studies assessing the net external costs have found mixed results. One US study, for instance, found that smokers – according to some of the scenarios applied in the study – could in fact be subsidising non-smokers, but that heavy drinkers and people leading sedentary lives do impose a net cost on society in some of the scenarios presented (Manning, Keeler, Newhouse et al. 1991; Keeler, Manning, Newhouse et al. 1989). The authors attributed those findings to the observation that the risk of early death associated with smoking is higher than for the other two behaviours.

In the case of heavy drinking, the value of lives lost due to alcohol-related accidents or violence added significantly to the external costs estimates (Manning, Keeler, Newhouse et al. 1991). Even so, neither the Manning (nor most other studies of this kind) took into account the critical costs of quasi-externalities (discussed next) that, if included, would substantially increase the overall estimate and thereby reverse the finding.

*Quasi-externalities*, the consequences of an individual’s poor health decisions to other family members, can be manifold. Economists traditionally considered these costs to be private and, hence, not policy-relevant; each family member was implicitly assumed to have identical preferences, or the household head was assumed to have incorporated all preferences of other family members into his or her behaviour and consumption choices. (Other household members were assumed to have ‘bargaining power’ that ensured consideration of their preferences, certainly a problematic assumption particularly in the case of children.)

A more recent view is that costs borne by household members other than those engaging in unhealthy behaviours should be considered as external. Because a large share of the costs of smoking and other unhealthy behaviours occur within households, adding these costs to any external cost estimate will greatly increase the external costs and thereby reinforce the rationale for government intervention (Sloan, Ostermann, Conover et al. 2004). Very few studies, however, have tabulated this cost component.

Before the costs of intra-household effects can be tabulated, it is important to identify what the effects are. Some are obvious and have been well documented, while others need more research. Perhaps the best example is second-hand smoke as studied by the

US Department of Health and Human Services (US DHHS 2006). Less obvious effects include those from inter-generational transmission, e.g., from mothers to their offspring in utero, with long-term economic effects. Such effects include the impact of smoking while pregnant on low birth weight, with the attendant potential consequences for future human-capital accumulation (Ernst, Moolchan and Robinson 2001; Torelli 2004). Other studies suggest that maternal nutritional status in pregnancy contributes to the development of obesity in children. Obese mothers appear more likely to have children with high birth weight, which tends to predict obesity in adolescence (Johannsson, Arngrimsson, Thorsdottir et al. 2006). That more work is needed to develop a scientific consensus on obesity-related effects is not surprising since obesity only recently became a major policy concern.

Social mechanisms also transmit chronic disease risks, and associated costs, from parent to children. Parental behaviour and education are perhaps the most important predictors of child health and behaviour. A similarly important social transmission occurs via ‘peers’ inside or outside the household (see Box 3 in Suhrcke, Nugent, Stuckler et al. 2006). Whether these effects of social transmission can be considered (quasi-)external is under debate.

In sum, the externality argument presents a straightforward, powerful rationale for public policy interventions. There is, however, too little evidence (especially in Europe) about whether externality presents a convincing argument in the case of chronic disease. Most of the existing studies consider the net external costs associated with unhealthy behaviour as not very large. Those costs, however, appear to be much higher (at least in the case of smoking) when intra-household effects are included (see Sloan, Ostermann, Conover et al. 2004 and Table 11 below). More work is needed to assess the extent to which this result carries over to other risk factors.

Table 11: Cost of smoking caused by a 24-year-old smoker in the US (in US\$)

	Mean cost per smoker	Cost per pack
Private cost	141,181	32.78
Quasi-external cost	23,407	5.44
External cost	6,201	1.44

Source: Sloan, Ostermann, Conover et al. (2004).

### *Departures from rationality*

The assumption that people act rationally (i.e., maximise their expected utility) represents a core pillar of economic thought that allows economists to derive ‘optimal’ behaviour in a normative sense. Models of rational behaviour can also explain and predict actual behaviour. Most economists would not approve dismissing the rationality assumption altogether, not least because doing so would open the way to paternalism in a broad range of areas – under the pretext of ‘helping people do what is best for themselves’.

Bearing these concerns in mind, economists and others recognise that in the specific case of children and adolescents, the rationality assumption does not hold (Chaloupka and Jha 2000). Children and adolescents tend not to take the future consequences of their choices into account, irrespective of whether they are informed of future consequences. They act ‘myopically’ and, hence, non-rationally. Their choices may well conflict with their long-term best interests. This provides – in principle – a justification for government intervention: to prevent them from harming themselves when they do not fully appreciate the consequences. Here, we do see privately borne costs that are relevant to public policy.

This rationale is also seen in light of the lasting impact that health and health behaviours in childhood and adolescence are known to have over a lifetime. This is most obvious in the consumption of addictive goods, particularly tobacco. Smoking behaviour is overwhelmingly established in adolescence. Some 80% of adult smokers in the US reportedly started smoking before the age of 18 (US DHHS 1994). Young people do not take into account the risk of becoming addicted to nicotine (again, even if informed of future consequences). This study also shows that the longer the onset of smoking is delayed, the less likely a person is to become addicted. Even absent addiction, empirical evidence strongly suggests that health behaviours, for example concerning diet and physical activity, adopted while young are reliable predictors of such behaviours in adulthood (Case, Fertig and Paxson 2005; van Dam, Willett, Manson et al. 2006; Whitaker, Wright and Pepe 1997).

Based on this justification, governments in many (mainly high income) countries have banned the sale of cigarettes and alcohol to minors to prevent their harm. Support and recognition are also growing in many countries for stronger regulation of advertising and sales of unhealthy foods to children (OfCom 2006).

### *Insufficient and asymmetric information*

There are typically good reasons to believe that markets fail to produce optimal outcomes because of informational problems. It is, however, important to distinguish between problems due to insufficient and those due to asymmetric information – despite the interrelations between the two. Asymmetric information occurs when one party to an exchange has private information that it deliberately withholds from the other party. Insufficient information is not deliberately withheld, but some individuals cannot use it or may interpret it incorrectly. These differences lead to very different policy recommendations: Asymmetric information requires a mechanism to induce the party withholding information to reveal it; insufficient information is corrected through comprehensive or targeted information campaigns.

Two key features of incomplete and asymmetric information are relevant in the context of chronic disease: 1) insufficient awareness of the health risks involved in consumption choices and 2) inadequate information about the addictive qualities of unhealthy goods. The former potentially applies to all unhealthy behaviours, while the latter is more relevant to smoking and alcohol consumption than diet and physical inactivity (but see Cawley [1999] for a treatment of the ‘addictive’ aspects of diet).

The costs in terms of health consequences for the individual must be separated into those the individual has foreseen and deliberately incurs, and those not foreseen. Both consequences are borne by the individual, but the latter did not enter into the utility-

maximising decision. Since the consumer unknowingly incurs internal costs, the issue becomes relevant to public policy.

Empirical findings as to whether individuals are well-informed appear mixed. Viscusi (1992 and 1999) found that smokers in the US over-estimated the health risks associated with smoking, while Schoenbaum (1997) found the opposite.<sup>25</sup> Cutler and Glaeser (2006) concluded that higher smoking levels in Europe (compared to the US) are largely explained by a continuing lack of information about the health consequences, even after a range of other determinants of smoking are taken into account.

Less work has assessed whether low risk awareness is a predictor of obesity. The evidence suggests that such awareness is low compared to that of smoking. In the US, for instance, Burton, Creyer, Kees et al. (2006) found that people tend to vastly underestimate the amount of calories and fat restaurants serve them. This is an important finding for high income countries, where restaurant portions are steadily increasing.

On the whole, government intervention in the form of the provision (and production) of health information is in principle justifiable, as information is a public good and as such will generally be undersupplied compared to the social optimum. This includes the role for government to engage in research about the health consequences of unhealthy behaviour. Many issues are only imperfectly understood, even on the science side. The history of smoking shows how better research can improve and expand evidence and its use. The surveillance of risk factors would also fall within governments' role as producers of information, given that private actors alone could not collaborate to provide this service. Such information can take many forms: product labelling, comprehensive or targeted public information campaigns, restricting the marketing of unhealthy food, etc. Perhaps the best example of the benefits of information is the sudden and sustained reduction in smoking in the US after the 1964 publication of the Surgeon General's Report on the health risks of tobacco consumption.<sup>26</sup>

However, were the information deficit reduced, evidence is mixed as to how much people's behaviour would change. Evidence from controlled experiments on the provision of nutrition information showed no effects on overall energy and fat intake (Kral, Roe and Rolls 2002; Stubenitsky, Aaron, Catt et al. 2000). Even perfectly informed people might consume unhealthy goods if the pleasure from consumption exceeds the short- and long-term costs, particularly if the private costs do not fully incorporate the full costs to society. In this case, simply providing more or better information will not produce the desired change in behaviour.

### *Time-inconsistent preferences or 'internalities'*

A potentially powerful justification for government intervention to prevent chronic diseases caused by unhealthy lifestyles comes from the recently proposed hypothesis of time-inconsistent individual preferences. Here, the individual chooses instant gratification over his or her long-term interests. This feature characterises only the

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25 This contradiction might relate to the questions asked: Viscusi's findings relied on the perceived risk in a hypothetical population of smokers, which may differ from the risks that smokers expect for themselves, Schoenbaum's focus.

26 Similar effects in other countries are reviewed in Kenkel and Chen (2000).

shape of individual preferences, while the other standard assumptions of economic theory remain in place: Individuals continue to be considered perfectly rational, forward-looking, fully informed consumers.

In this model, a commitment made today – by a perfectly informed and rational individual with time-inconsistent preferences – to act in a particular way in the future will be broken when the time comes to respect the commitment. For example, a smoker who declines to stop smoking immediately might agree to stop in a year. A year later, he/she prefers to continue smoking rather than meet the commitment.<sup>27</sup> When the future arrives, the preference for instant gratification prevails. In other words, the individual's present and future selves disagree. Since the decisions of the present self discount the consequences of its actions on the future self, it imposes a type of externality on the future self. This is called an 'internality' or 'intra-personal externality' because the consequences remain 'inside' the individual, albeit denied by the current self.

The US provides some empirical evidence on time-inconsistent preferences. Eight out of 10 smokers express the desire to stop, but many fewer actually do. Gruber (2002) reports that over 80% of smokers try to quit annually, the average smoker tries to quit every eight months, and 54% of serious cessation attempts fail within a week.

The contrast between the current and future self can be indirectly detected in the well-documented difficulty of committing to diets. Cutler, Glaeser and Shapiro (2003, p.112–113), examining the US case, argue that eating decisions often appear inconsistent:

People overeat, despite substantial evidence that they want to lose weight. The diet industry has \$40–\$100 billion in annual revenues .... Food brings immediate gratification, while health costs of overconsumption occur only in the future. Maintaining a diet can be very difficult. People on diets frequently yo-yo; their weight rises and falls as they start and stop dieting.

They found further confirmation of the time-inconsistency theory in the fact that desired weight rises only slightly as actual weight rises, particularly for obese people, increasing the disparity between how individuals actually are and how they would like to be.

It is difficult to assess the size of internalities, as they depend on the not-directly-observable degree of time inconsistency displayed by the individual. The upper limit is given by the total health costs that individuals impose upon themselves. Gruber and Koszegi (2001 and 2002), using the value-of-life valuation method, estimated that the total harm that smokers do to themselves equals US\$ 35 per pack of cigarettes – a very high figure. Of that amount, the internal costs for 'modest' degrees of time inconsistency (below the assessments of most laboratory experiments) would be US\$ 1–2 per pack. For more severe time inconsistency (still consistent with experimental evidence), the internal costs are estimated at about \$5–\$10 per pack.

Time-inconsistent preferences may justify an intervention (e.g., a tax) to induce people to do what they want but are unable to do alone. The size of the internal costs could suggest the size of an optimal tax, in addition to any tax that might be justified by the presence of external costs. Gruber (2002) estimated that external costs would convert to a tax of \$0.40 per pack or less – much less than the US\$ 35 internal costs.

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27 In the first decision, the discount factor applied to the value of future health improvements is low enough to make the individual opt for the present enjoyment of one more year of smoking, and the discount rate applied is high enough to make the individual 'decide' to quit after a year and enjoy health improvements.

Time-inconsistency is easily confused with insufficient information (or myopic behaviour), especially with addictive goods. The outcomes of these market failures may be identical, but the causes – and hence the policy implications – differ significantly. While the solution to limited information is to provide more (in particular, to young people), the solution to time-inconsistency is to provide effective commitment devices: a mechanism that reinforces a previously adopted decision. For example, individuals can bet on their ability to stop smoking or announce publicly their willingness to quit. Unfortunately, lacking external force, such devices are weak.

Taxes can provide a commitment device.<sup>28</sup> They increase the immediate cost of unhealthy behaviours, thereby lowering the individual's enjoyment (or present benefit). Taxes that adjust for time-inconsistent preferences may be considered as welfare improving because they provide individuals who have little self-control with an effective commitment device and a way to increase their utility surplus. If the tax proceeds are returned evenly society-wide, individuals with high self-control are compensated for their loss of enjoyment, thereby reinforcing self-control (O'Donoghue and Rabin 2006).

Taxation addresses the internality problem in a way similar to that whereby traditional economic models respond to externalities. The smoker's response to the price increase will be the same in both the standard model and in the case of time inconsistency: he or she will reduce smoking. However, a crucial – and in principle empirically testable – difference is that in the case of time-inconsistent preferences, smokers will be better off because they are 'forced' to do what they ultimately want: smoke less. By contrast, the standard model predicts that smokers will be worse off because the government is constraining their rational choice. Gruber and Mullainathan (2002) found some support for the time-inconsistency model in both the US and Canada in that higher cigarette taxes were associated with higher levels of self-reported well-being among smokers.

Gruber (2002) suggests that taxes should be accompanied by other measures to reduce the present enjoyment of smoking, such as banning smoking in public places or the workplace. This suggestion can be generalised to cover the full set of unhealthy behaviours by introducing measures that change the incentives of private decision-making without prohibiting unhealthy choices. Individuals' self-control would be reinforced, achieving the effect of a commitment device while conserving freedom of choice.

Note that while private benefits are (by definition) outside the scope of public intervention, both immediate and future costs can be manipulated to make healthy choices easier. Wider use of standardised nutritional certification programmes would reduce the time costs of gathering nutritional information, at least among those able to act upon such information. Wide availability of running lanes, gyms, swimming pools and cycle paths would reduce the cost of physical activity by reducing search and transportation costs. Price policies may also be an option to influence food choices, by reducing the relative price of healthier foods through subsidies or by taxing unhealthy foods. This requires, however, a careful analysis of the welfare implications (see e.g., Schmidhuber 2004).

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28 Courts can also (indirectly) introduce a type of 'tax'. The US courts, for instance, required the tobacco industry to pay large damages to deceased smokers' families, which raised the per-pack price by \$1.31 between 1997 and 2002, while the tax rose only \$0.21 (Gruber 2002).

Overall, while the idea of time inconsistency as a market failure is highly plausible, more research should establish an empirical basis for the argument in the case of chronic disease risk factors. It is, however, an argument that could justify an acceptance of some of the substantial internal costs incurred through poor health habits as relevant to public policy, significantly reinforcing the case for government intervention.

To summarize this section, three arguments – time-inconsistency (instant gratification), departures from reality (especially in the case of youth) and imperfect information (insufficient or withheld) may justify recognition of some of the large internal costs of chronic disease as relevant to public policy. In addition, certain external costs may justify intervention, especially quasi-externalities (family members) and externalities resulting from poor health habits in collectively financed programmes.

Whether governments have the means to correct market failures at a cost worth the return is another matter. Many interventions might not meet this criterion, in which case the optimal choice would be to live with the status quo. What is needed is evidence on the cost-effectiveness of interventions (briefly covered in Section 4 and extensively in Schwappach, Boluarte, Suhrcke et al. [2006]). Indeed, the link between the market failure and cost-effectiveness is key: Evidence of cost-effectiveness alone is *not* sufficient to justify a role for *public* policy. Both must be present.

## Section 6: Conclusions

We have sought to complement the ongoing health policy debate, which focuses almost exclusively on the cost of health systems, to include the benefits. We also looked more closely than most at the benefits that may be derived from preventive, as opposed to curative, approaches. Both the existing empirical evidence on the costs associated with ill health (or the benefits associated with good health) and our ‘back-of-the-envelope’ calculations show that substantial benefits would derive from improved health, with much of that achievable via effective prevention efforts.

The prospect of such possibly sizable benefits provokes two further questions:

- 1) *What should a cost-effective prevention programme look like, based on the available evidence?*

For the parallel, Schwappach et al. (2006) paper, we systematically reviewed the empirical evidence on economic evaluations of primary prevention – with a focus on cardiovascular disease. On the positive side, we found that there *is* evidence on the cost-effectiveness of some such preventive interventions – a finding consistent with other reviews of health economic evaluations. Smoking cessation and taxation have long been known as highly cost-effective interventions, particularly when addressing youth smoking. A similar conclusion applies to selected population-based interventions, such as salt legislation and educational campaigns (under some circumstances).

Nevertheless, significant gaps in the literature call for more research to better inform a full-scale, comprehensive prevention programme. The production of evidence – in particular on population-based, non-clinical preventive interventions – represents a

public good that (by definition) the market cannot provide at socially optimal levels. Numerous preventive interventions that are known or considered ‘effective’<sup>29</sup> have not undergone cost-effectiveness tests.

In sum, while there are certainly parts of a prevention programme that offer sufficient prospect for good returns based on the available cost-effectiveness evidence, not surprisingly there remains scope for more research to inform the priorities of an entire, comprehensive prevention programme in the specific context of Germany.

## 2) *Who should take the initiative on prevention?*

We found justification for an explicit government role in the prevention of lifestyle-related morbidity and mortality, as well as on research on prevention. Market failures argue for government to play a role in fostering behaviour change, based on strict economic efficiency grounds. Nevertheless, we note that governments must carefully choose which interventions to implement, maximising the value for the money invested while ensuring other, ideally, equally valuable and transparent policy objectives. We also posit that more information is needed to make such choices, some of which can be gained through phased-in implementation in areas where the available evidence does not reach far enough.

We offer a caveat that this report was based on a limited exercise and could not explore the details of all relevant aspects. Clearly, there is still work to be done to lay the groundwork for a successful approach to prevention – in Germany or in Europe more generally – that is informed by solid epidemiological, public health and not least economic evidence. Given the stakes, in the form of expected health and economic benefits that we have demonstrated, such work would be eminently worthwhile.

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29 See IUHPE (2000) for an extensive review of effective health promotion interventions.

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## Annexes

### *Annex 1: Background tables*

**Table A 1: Diseases ranked by share of male mortality, all ages, under 70 and under 60:  
Germany, 2002**

Rank	Condition	% of all age mortality	Condition	% of deaths < 70	Condition	% of deaths < 60
1	Cardiovascular diseases	41.9	Malignant neoplasms	35.3	Malignant neoplasms	29.9
2	Malignant neoplasms	30.0	Cardiovascular diseases	30.4	Cardiovascular diseases	24.0
3	Digestive diseases	5.7	Digestive diseases	8.5	Digestive diseases	10.3
4	Respiratory diseases	4.8	Unintentional injuries	5.4	Unintentional injuries	9.8
5	Neuropsychiatric conditions	3.5	Neuropsychiatric conditions	4.9	Intentional injuries	7.8
6	Unintentional injuries	3.1	Intentional injuries	4.4	Neuropsychiatric conditions	7.3
7	Respiratory infections	2.4	Respiratory diseases	3.2	Infectious and parasitic diseases	2.3
8	Intentional injuries	2.3	Infectious and parasitic diseases	1.8	Respiratory diseases	2.0
9	Diabetes mellitus	2.0	Diabetes mellitus	1.8	Diabetes mellitus	1.3
10	Infectious and parasitic diseases	1.5	Respiratory infections	1.2	Perinatal conditions	1.3

**Table A 2: Diseases ranked by share of female mortality, all ages, under 70 and under 60:  
Germany, 2002**

Rank	Condition	% of all total deaths	Condition	% of deaths < 70	Condition	% of deaths < 60
1	Cardiovascular diseases	52.7	Malignant neoplasms	47.0	Malignant neoplasms	46.6
2	Malignant neoplasms	23.8	Cardiovascular diseases	23.5	Cardiovascular diseases	15.5
3	Digestive diseases	4.6	Digestive diseases	7.1	Digestive diseases	8.6
4	Respiratory diseases	3.1	Neuropsychiatric conditions	3.7	Unintentional injuries	6.0
5	Diabetes mellitus	3.0	Unintentional injuries	3.6	Neuropsychiatric conditions	5.1
6	Respiratory infections	2.7	Intentional injuries	2.9	Intentional injuries	4.9
7	Neuropsychiatric conditions	2.6	Respiratory diseases	2.9	Respiratory diseases	2.3
8	Unintentional injuries	2.0	Infectious and parasitic diseases	2.0	Infectious and parasitic diseases	2.1
9	Infectious and parasitic diseases	1.4	Diabetes mellitus	1.8	Congenital anomalies	2.0
10	Genitourinary diseases	1.4	Respiratory infections	1.0	Perinatal conditions	2.0

Table A 3: Diseases ranked by DALYs for males, all ages, under 70 and under 60, as a percentage of all in the respective age category: Germany, 2002

Rank	Condition	% of all total DALYs	Condition	% of DALYs <70	Condition	% of DALYs <60
1	Neuropsychiatric conditions	24.3	Neuropsychiatric conditions	27.8	Neuropsychiatric conditions	34.6
2	<b>Cardiovascular diseases</b>	20.8	<b>Cardiovascular diseases</b>	16.2	<b>Cardiovascular diseases</b>	11.6
3	Malignant neoplasms	17.7	Malignant neoplasms	16.2	Malignant neoplasms	11.5
4	Digestive diseases	6.1	Unintentional injuries	6.7	Unintentional injuries	8.5
5	Unintentional injuries	5.6	Digestive diseases	6.7	Digestive diseases	6.7
6	Respiratory diseases	5.6	Respiratory diseases	5.5	Respiratory diseases	5.5
7	Sense organ diseases	4.5	Sense organ diseases	4.8	Intentional injuries	4.3
8	Musculoskeletal diseases	3.3	Intentional injuries	3.5	Sense organ diseases	4.3
9	Intentional injuries	2.9	Musculoskeletal diseases	3.5	Musculoskeletal diseases	3.4
10	Diabetes mellitus	1.9	Diabetes mellitus	1.8	Infectious and parasitic diseases	1.8

Table A 4: Diseases ranked by DALYs for females for all ages, under 70 and under 60, as a percentage of all in the respective age category: Germany, 2002

Rank	Condition	% of all total DALYs	Condition	% of DALYs <70	Condition	% of DALYs <60
1	Neuropsychiatric conditions	28.1	Neuropsychiatric conditions	33.4	Neuropsychiatric conditions	39.9
2	<b>Cardiovascular diseases</b>	18.8	Malignant neoplasms	16.9	Malignant neoplasms	13.4
3	Malignant neoplasms	17.0	<b>Cardiovascular diseases</b>	9.1	Respiratory diseases	6.8
4	Sense organ diseases	5.5	Sense organ diseases	6.5	<b>Cardiovascular diseases</b>	5.7
5	Musculoskeletal diseases	5.5	Respiratory diseases	6.1	Sense organ diseases	5.2
6	Respiratory diseases	5.2	Musculoskeletal diseases	6.0	Digestive diseases	5.1
7	Digestive diseases	5.0	Digestive diseases	5.3	Musculoskeletal diseases	5.1
8	Unintentional injuries	3.0	Unintentional injuries	3.7	Unintentional injuries	4.4
9	Diabetes mellitus	2.0	Infectious and parasitic diseases	1.9	Infectious and parasitic diseases	2.1
10	Infectious and parasitic diseases	1.6	Diabetes mellitus	1.6	Intentional injuries	1.8

**Table A 5: DALYs caused by various cardiovascular diseases among males: Germany, 2002**

	0-4	5-14	15-29	30-44	45-59	60-69	70-79	80+	Total	% total	
Rheumatic heart disease		80	37	226	515	955	1821	1415	381	5430	0,1
Hypertensive heart disease		79	0	295	1884	7190	9340	9824	6010	34622	0,6
Ischaemic heart disease		2	153	2758	36670	126584	171890	148385	49086	535529	9,8
Cerebrovascular disease		275	249	1890	23546	50415	76611	74518	27415	254918	4,6
Inflammatory heart diseases		856	517	2357	9319	16723	17259	8459	1523	57013	1,0
Other cardiovascular diseases		906	1052	7125	31242	52402	63405	62336	37508	255976	4,7
All CVD		2198	2008	14650	103177	254268	340326	304937	121924	1143488	<u>20,8</u>

Source: Unpublished GBD national estimates from WHO.

**Table A 6: DALYs caused by various cardiovascular diseases among females: Germany, 2002**

	0-4	5-14	15-29	30-44	45-59	60-69	70-79	80+	Total	% total
Rheumatic heart disease	37	74	148	174	876	2286	3139	1644	8379	0,2
Hypertensive heart disease	37	2	132	1035	3413	6633	15144	22780	49177	1,0
Ischaemic heart disease	0	236	2301	9109	27600	65014	126178	105323	335762	6,8
Cerebrovascular disease	186	146	1461	16526	27875	46387	92543	73857	258981	5,3
Inflammatory heart diseases	823	268	985	2459	4008	5607	5676	2740	22565	0,5
Other cardiovascular diseases	668	562	4935	17669	24576	33945	74438	95298	252090	5,1
All CVD	1751	1289	9963	46973	88348	159872	317118	301640	926953	<u>18,8</u>

Source: Unpublished GBD national estimates from WHO.

**Table A 7: Average contribution of the 7 major risk factors to the disease burden in developed countries for 7 major chronic conditions, in percentages**

Condition	Contribution in percentage of individual risk factors							
	High blood pressure	Tobacco	Alcohol	High cholesterol	Over-weight	Low fruit/veg intake	Physical inactivity	Other known factors
1. Ischaemic heart disease	58	22	0.2	63	33	28	22	
2. Unipolar depr. disorders			3					4
3. Cerebrovascular disease	72	22	0	27	23	12	9	
4. Alcohol use disorders			100					3
5. Chronic pulmonary disease		69						2
6. Road traffic injury			38					8
7. Lung cancer		85				11		

Source: Modified after Ezzati et al. (2004) , WHO Regional Office for Europe (2005).

**Table A 8: CVD health care costs by EU country, 2003**

Country	Cost per capita (€)	Percentage of total health care expenditure
<b>Germany</b>	<b>422.95</b>	<b>15</b>
UK	368.37	18
Sweden	317.84	12
Netherlands	272.93	11
Luxembourg	255.41	8
Austria	246.53	11
Finland	234.95	12
Denmark	215.45	7
Italy	203.97	11
Belgium	200.6	8
France	194.31	8
Greece	139.86	11
Ireland	108.18	4
Spain	96.66	7
Portugal	93.15	8
Czech Republic	83.03	14
Slovenia	79.52	8
Cyprus	67.03	7
Estonia	54.84	17
Hungary	52.30	9
Slovakia	51.82	18
Poland	46.15	16
Lithuania	43.45	16
Latvia	23.75	11
Malta	21.65	2
<b>TOTAL EU</b>	<b>230.42</b>	<b>12</b>

Source: Petersen, Petro, Rayner et al. (2005).

**Table A 9: Direct medical costs of Type II diabetes: 8 European countries, 1999**

Country	Total cost per country (€)	Mean cost per patient (€)	Percentage of total health care expenditures*
Belgium	1,093,652,291	3,295	NA
France	3,983,000,000	3,064	3.4
<b>Germany</b>	<b>1,243,745,000</b>	<b>3,576</b>	<b>6.5</b>
Italy	5,170,028,166	2,991	6.6
Netherlands	443,915,000	1,827	1.6
Spain	1,957,785,697	1,305	NA
Sweden	736,000,000	2,630	NA
UK	2,609,799,104	2,214	2.5
Average		2,834	

\* Using 1997 total current expenditure on health.

Source: Jönsson (2002)

## *Annex 2: Technical Notes: WHO estimates for disease burden, Europe*

EUR-A is regional sub-group of 27 countries in or near Europe with very low child mortality and very low adult mortality: Andorra, Austria, Belgium, Croatia, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland and the UK.

New life tables and a detailed distribution on causes of death were calculated for all 192 WHO Member States for 2002 (Mathers, Bernard, Iburg et al. 2003). Since comparable prevalence data for health conditions are not available for all countries, a three-step procedure was used to derive the best possible assessment of the prevalences. First of all, data from the Global Burden of Disease study (GBD) was used to estimate prevalence of conditions according to their relative severity on age and sex for these countries. Secondly, survey data from the Multi-Country Survey Study (MCSS) was applied to obtain alternative estimates of prevalences, adjusted for severity on age and sex for 60 countries, including all EU countries (Ustun, Chatterji, Villanueva et al. 2003; Salomon, Murray, Ustun et al. 2003). A newly developed method used anchored vignettes for hypothetical health states linked to self-reported own health status (Salomon, Tandon and Murray 2004). The idea is both to identify and to adjust for differences in expectations across age groups, sex and countries in order to make self-reported health data more comparable. Finally, prevalences for all countries were estimated on basis of the GBD prevalences and the survey prevalences. Furthermore, adjustments were made for comorbidity and degree of institutionalisation of the populations (Mathers, Murray and Salomon 2003; Mathers, Iburg and Begg 2006).

One DALY can be understood as one healthy life year lost and the burden of disease as a measure for the gap between the actual health status and an ideal situation where everyone lives to old age without disease or injury. For each disease or injury, DALY is calculated as the sum of years of life lost (YLL) in the population due to premature death and years lost due to new cases (incidence) of that disease/injury (YLD). The total of years of life lost (YLL) equals the number of deceased multiplied by a standard life expectancy at the age when the death occurs. The basic formula for YLL for a given cause by sex and age is:

$$YLL = N * L$$

where:

N = number of deceased

L = standard life expectancy at age of death

When YLL is measuring the stream of new lost years of life due to mortality, an incidence perspective is also taken for the calculation of years lost due to diseases and injuries (YLD). To estimate YLD for a specific cause over a certain time period, the number of new cases is multiplied by the average duration of the disease and a weighting factor that reflects the severity of the disease or injury on a scale from 0 (perfect health) to 1 (deceased). The basic formula for YLD is:

$$YLD = I * DW * L$$

where:

I = number of new cases

DW = disability weight

L = average duration of the disease until recovery or death (years)

Principles of equality are explicitly built into DALY, and the same values are applied for all regions of the world (Murray 1996). The same ideal for life expectancy is used for all population groups, and all characteristics that are not directly related to health (for example ethnicity, socio-economic status and employment) are excluded (except age and sex in the calculation of years lost to disease/insury). The same disability weights are used for everyone living a year in a specific state of health. Also applied are a 3% time discounting and age weights that give less value to years lived in youth and old age.

The new burden of disease estimates presented here should be seen as the best estimates the World Health Organization (WHO) could derive from available evidence in mid-2003, rather than as the official estimates from a member country. In the WHO estimations, standard classifications were used together with a new methodology to obtain cross-national comparability, so the results will not necessarily equal official national estimates. WHO estimates were originally made on an overall regional level (EUR) and on sub-regional levels (EUR-A,-B and -C) and then afterwards disaggregated to country level. The country-specific results will therefore be less certain due to limitations in data availability and the epidemiological assumptions used in the statistical modelling.

The work that led to the new burden of disease estimates used here was performed by WHO headquarters in Geneva (Global Programme on Evidence for Health Policy) in collaboration with WHO's technical programmes and researchers worldwide. Documentation and summary tables are available at [www.who.int/evidence/bod](http://www.who.int/evidence/bod)), together with software and a National Burden of Disease Manual that gives guidelines to perform a national burden of disease study (Mathers Vos, Lopez et al. 2001).

### *Annex 3: Derivation of Revealed Preferences for Demand of Health Goods: Calculating the Value of a Statistical Life*

This annex provides a theoretical foundation for the demand of health goods and services and the amount a population is willing to pay, on average, for them in dependence of an increase in life expectancy. Willingness to pay for health goods and services is not directly measurable, but consumer theory enables us to derive a revelation principle, which helps us indirectly measure the true preferences for health goods and services.

We begin with a highly simplified model framework of a representative agent's optimal consumption and work supply decisions in the presence of life risk in an intertemporal decision problem to obtain a lower-boundary value for the value of a statistical life year. We then extend this model framework to explicitly integrate labour and work life risk supply with consumption and health goods and service production where health goods and services have an impact on the survival function of the representative agent.

***Lower boundary for the value of a statistical life year:*** We consider a representative agent who optimises expected period utility  $W$  over a lifetime.

$$(1) \quad W(A) = \sum_{a=A+1}^{\infty} u(c(a); l(a)) \cdot S(a|A) \rho^{a-A}$$

Expected lifetime is characterised by a period survival rate  $S(a|A)$  in dependence of age  $A$  and year  $a$ . Period utility  $u(c(a); l(a))$  depends on both consumption  $c(a)$  and leisure  $l(a)$  and adheres to the usual assumptions. One year minus leisure is consequently the labour supply of the representative agent in a year. The exogenous time preference rate is denoted  $\rho$ .

We close the model by assuming that the consumption good is produced according to:

$$(2) \quad c(a) = f(1-l(a)),$$

where the production function  $f(\cdot)$  has the property of decreasing returns to scale.<sup>30</sup>

Henceforth, we assume that the period survival rate is characterised by a Poisson process (as in e.g., Nordhaus 2003). This implies a constant mortality rate  $\mu$  independent of age.

$$(3) \quad S(a|A) = (1 - \mu)^{a-A}$$

---

30 The standard assumption is constant returns to scale. However, this is equivalent to our assumption if there exists some fixed factor. A model without a fixed factor and decreasing returns is equivalent to one with constant returns explicitly modelling the fixed factor.

This assumption, while standard, is a severe restriction. One objection is that the expectancy of future life years at birth is identical to this expectancy of – say – a 60-year-old. Yet, it is an assumption that is often invoked (e.g., Nordhaus 2003). As long as we restrict our analysis to a representative individual of the economy, our results remain quite close to calculations that drop this assumption and assume mortality processes that exactly mirror the true demographics (see Murphy and Topel 2005): Consumption smoothing will largely even out differences in expected utilities across periods. Any age-dependent characteristics that influence period utility will have only a dampened impact. However, both the assumption of a constant survival rate and the assumption of a representative agent (absent individual heterogeneity) will not permit us to differentiate the willingness to pay for health goods and services according to subgroups of society.

The expression for life expectancy at birth follows immediately from the assumption of a constant survival rate:

$$(4) \quad E[A] = \sum_{a=1}^{\infty} S(a|A) = \frac{1}{\mu}$$

Assuming a life expectancy at birth of roughly 80 years, which is sufficiently close for our purposes to the German average of 78 years, we obtain immediately from (4) an annual average mortality rate of 0.0125. This serves as our benchmark mortality rate in the following analysis.

In addition to the demographic assumption, our simplified model has the shortcoming that it does not permit for life-cycle income patterns: e.g., there is no retirement period consistent with the assumption of a constant survival rate. Again, consumption smoothing dampens any adverse effects from life-cycle income on our results. Moreover, we consider only a steady-state analysis. We will thus not be able to say anything on transition periods. Ultimately, we ignore savings and investment decisions that are potentially important.

The representative agent in this economy solves thus the following intertemporal optimisation problem:

$$(5) \quad \max_{c(a), l(a)} W(A)$$

subject to the budget constraint

$$(6) \quad c(a) = w(a)[1-l(a)]$$

where the production goods price is normalised without loss of generality to one.

The first-order conditions are standard:

$$(7) \quad u_l^* = w \cdot u_c^*$$

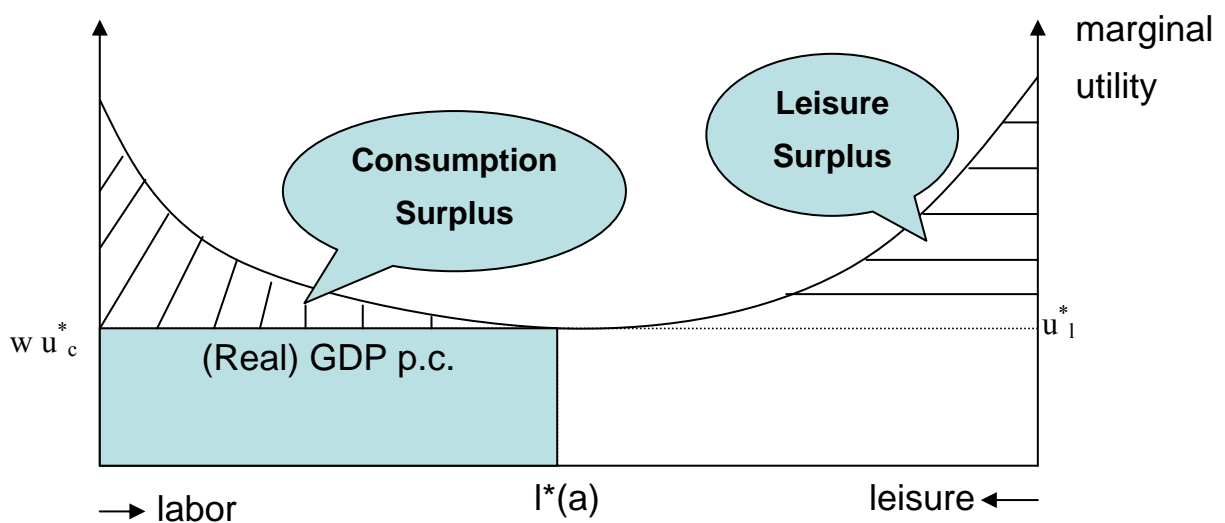
Equation (7) has a simple economic interpretation: At the optimal allocation of work and leisure time, the marginal utility of an additional unit of leisure must be equal to the marginal utility of the amount of the consumption good that could be bought by working this time unit, receiving a wage  $w$  and spending it on consumption goods.

Next, we pose the question, What would the increase in lifetime utility be if the current survival rate marginally increased.

$$(8) \quad \frac{\partial W(A)}{\partial S(A)} = u(c(A); l(A))$$

Quite interestingly, an increase in the survival rate increases the present value of life-time welfare just by the period utility function. This result is analogous to Nordhaus (2003). The willingness to pay for any good or service that prolongs life expectancy is just measured by the utility units that the individual would enjoy during the extra period of life. Of course, there is no direct measure of utility units, but we can give a lower boundary of the nominal value from the utility units of lengthening life expectancy by one year.

Figure A 1: Lower boundary of the economic value of a one-year increase in life expectancy



Source: Authors

Figure A 1 depicts period utility per time unit spent on either leisure or work where the wage income is spent entirely on the consumption good, which in turn yields utility. The length of the box in the figure depicts the entire time budget, e.g., 365 days times 24 hours, or deducting sleeping time (which is not really disposable), 365 days times – perhaps – 16 hours. The time spent at work is depicted on the horizontal axes from the left, beginning with the first minute of work. Leisure time is depicted from the right, beginning from the first minute of leisure during the course of a year. The optimal leisure time is depicted at  $l^*(a)$ . The distance between  $l^*(a)$  and the origin measures the supply of labour. At the locus  $l^*(a)$ , the marginal utility of working an additional unit of time is just the wage times the marginal utility out of consumption according to (7). Any minute of work before  $l^*(a)$  will yield a marginal utility of work above this benchmark by the law of decreasing utility. In fact, the total utility out of consumption is the area below the curve to the left of  $l^*(a)$ . This area can be divided into the rectangle of wages  $w$  times marginal utility out of consumption  $u^*_c$  times labour  $[1-l^*(a)]$  and the area between the curve and the rectangle which is consumer surplus. The monetary equivalent to the utility units corresponding to the shaded rectangle is nothing else but (real) GDP. The period utility measured in monetary equivalents must thus be larger than real GDP.

The usual GDP measure does not take into account the utility gain from leisure time. This gain is depicted in the figure to the right of  $l^*(a)$ . While to the left, there is utility derived from producing, earning a wage and spending it on the consumption good. To the right of  $l^*(a)$ , utility is derived directly from leisure. At the locus  $l^*(a)$ , the marginal utilities of consumption and leisure must be equal. At any lower level of leisure to the right of  $l^*(a)$ , the marginal utility of leisure must be larger by the law of decreasing marginal utility.

We define now the value of a statistical life as the monetary equivalent to the present value of the life-time welfare. To simplify analysis here, we ignore discounting. Then, we can provide a ‘back-of-the-envelope’ calculation for the lower boundary of the value of a statistical life. Suppose in rough terms that working life extends from age 20 to 60, that the labour force participation rate is 80% (to get smooth numbers), and that there are 220 working days per year and 8 working hours per work day on average. Then, the ratio of working to leisure time is as much as one to eight. Hence, the value of a statistical life is, on average, 8 times GDP per capita (roughly €30,000) or €240,000. This can be regarded to a lower boundary. In fact, typical estimates for the US obtained through other calculations are well above this value, i.e., often several million dollars.

***Revelation of the value of a statistical life year:*** We now turn to a model extension that serves to derive a revelation principle for the optimal health goods and services expenditure. For this purpose, we extend the previous model in two respects. First, we endogenize the mortality rate  $\mu$ . We assume that the mortality rate, though still constant over time in the steady state, depends on the health expenditure  $H(a)$  and the amount of work-life risk ( $L(a)$ ) in terms of a change in the mortality rate per year.

$$(9) \quad \mu(a) = \mu(H(a); L(a)) \quad \text{where} \quad \frac{\partial \mu}{\partial H(a)} < 1 \quad \text{and} \quad \frac{\partial \mu}{\partial L(a)} = 1$$

We assume that there are riskier jobs to choose from and less risky ones. The riskier ones pay a mortality risk premium  $R(a)$  per unit of mortality risk.

The second change concerns the budget constraint. We assume that health goods and services are perfect substitutes to consumption goods and produced by the same technology. Then, we have the budget constraint:

$$(10) \quad c(a) + H(a) = w(a) \cdot [1 - l(a)] + R(a) \cdot L(a)$$

The expenditure on consumption and health will have to be paid out of work income from giving up leisure and taking up life risk at work.

The welfare maximisation problem changes finally to

$$(11) \quad \max_{c(a), l(a), H(a), L(a)} W(A)$$

The representative agent has to choose in addition to optimal consumption and leisure the optimal health expenditure  $H(a)$  and the optimal amount of work-mortality risk  $L(a)$ .

This setup has important shortcomings that have to be kept in mind. First, we do not allow health expenditure to directly influence the utility function, which would be the case if health expenditure directly increased life quality (e.g., pain relief). Second, we do not allow health expenditure to influence labour productivity, although it is obvious that some health expenditure is devoted to re-establishing work capabilities (e.g., through rehabilitation). Also, this part of health expenditure is henceforth ignored. See Murphy and Topel (2005) for more on these two points.

Turning to the optimality conditions, we note first that the labour/leisure choice is not affected by the extensions. However, additional optimality conditions emerge. In particular, the optimal health expenditure is given by:

$$(12) \quad \frac{\partial S / \partial L}{\partial S / \partial H} = R(a)$$

The absolute value of the marginal change in the survival rate of a marginal change in life risk through work can be normalised without loss of generality to one, i.e.,  $dS/dL = -1$ . Then, (12) reduces to

$$(13) \quad \frac{\partial H}{\partial S} = -R(a)$$

Equation (13) has a simple interpretation. The health expenditure necessary to increase the survival rate by a percentage point should equal the life risk premium of taking up mortality risk in a job by the same measure of risk. Re-stated in units of measurement, we have:

$$(14) \quad \frac{X \text{ Euros Health Expenditure}}{\frac{1}{10000} \text{ Mortality Rate Decrease}} = \frac{\text{Wage Mortality Risk Premium}}{\frac{1}{10000} \text{ Mortality Rate Increase}} = R(a)$$

The wage risk premium per mortality rate *increase* is at the same time the optimal health expenditure per mortality risk *decrease*. By the assumption of a steady state analysis, this equation holds independently of the year *a*.

We are now ready to turn to the revelation principle. If in the optimum,  $R(a)$  units of health expenditure reduce life risk by a factor  $1/10,000$  per year, then there will be one individual's life certainly saved by the law of large numbers if 10,000 individuals all spent the amount  $R(a)$ . Hence, we define the value of a statistical life year as  $10,000 * R(a)$ , where  $R(a)$  is the mortality risk premium on the job paid per increase of the mortality rate by the factor  $1/10,000$ . In short:

$$\begin{aligned} & \text{Value of 1 year of statistical life} \\ & = 10000 \cdot \text{wage mortality premium per } 1/10000 \text{ mortality risk increase per year} \\ & = \text{health expenditure to save one life for during a year} \end{aligned}$$

**Measuring the value of a statistical life year:** To obtain the optimal health expenditure that an individual is willing to pay for an increase in one unit of life expectancy, we need to have an estimate of the work risk premium  $R(a)$ . We do not observe this premium directly. Instead, it is one out of many components of the total wage or more precisely:

$$(15) \quad \text{market wage } (i,j) = w(i,j) + R * L(j),$$

where  $w(i,j)$  is the component of the market wage that compensates for the loss of leisure time, and controlled for productivity differences of workers *i* and differences in job characteristics *j*.  $L(j)$  is the mortality risk associated with job *j*. We observe typically the market wage and the risk characteristics of the job, but not the component  $w(i,j)$  or the mortality risk premium  $R$ . Hence, the component  $w(i,j)$  needs to be estimated by controlling for job and worker characteristics. Then, the value for the mortality risk premium is easily obtained from (15) as a residual. The estimation of the wage that the same worker at the same type of job but with lower work mortality risk would have received is intricate econometrically. It is typically done in a Mincer wage regression, which has the following form:

$$(16) \quad \text{market wage } (i,j) = a * \text{personal characteristic}(i) + b * \text{job characteristic}(j) + R * L(j) + \text{error},$$

where *a* and *b* are regression coefficients.

The most recent estimate of the wage regression (16) for Germany was undertaken by Schaffner and Spengler (2005). They used two independent datasets on the Socio-Economic Panel (SOEP) and data from Institut für Arbeit und Bundesagentur für Arbeitsmarkt- und Berufsforschung Beschäftigtenstichprobe (IABS) and applied panel data methods that control to some extent for unobservable individual heterogeneity. The IABS data cover the period 1971–95 and the SOEP data the period 1985–95. No estimates on more recent data exist, but we do not expect this to have a serious impact on the results. Their estimates are somewhat lower than the ones typically obtained without such a control. The benchmark estimates on both datasets are quite close to each other and indicate a mortality risk premium of 10% entailed in the wage. The average wage in the sample is €30,300 denoted in 2001 prices. Hence, we obtain a mortality risk premium per 1/10,000 of mortality risk increase per year of €303. This corresponds to the value of a statistical life year of €3.03 million. The estimates vary, however, between €2 and €10 million depending on the sample and the estimation techniques. All these values are – consistent with theory – considerably larger than the lower bound of about €240,000 that we calculated in the previous subsection.

To understand the economic meaning of the obtained estimates better, we can interpret them as follows: When we assume that the probability of dying is constant, then the probability of dying is reciprocal to the expectancy of future life years according to (4). For example, a probability of dying per year of 0.0125 corresponds to a life expectancy at birth of 80 years ( $=1/0.0125$ ), sufficiently close for our purposes to the actual German average life expectancy of 78 years. A reduction of life risk by 1.5/10,000 would thus increase life expectancy at birth by about a year.

A representative German would thus be willing to pay €490 per year in 2006 prices for a one-year increase in life expectancy. (The above-derived €3.03 million \* 1.078 \* 1.5/10,000 = €490)<sup>31</sup>

When taking the estimates at face value, it is important to be aware of the estimation shortcomings. First, there are other disamenities typically associated with life-threatening activities. For example, coal miners not only suffer from health risk but also from uncomfortable work conditions, so the wage risk premium may actually capture compensation components in addition to mortality risk. If so, our life risk premium is overestimated. Also, a job's riskiness may vary considerably over time, causing a particular profession to have more mortality cases in some years than others. For the estimates, an average value is taken. This implies, however, that the mortality risk characteristics themselves are estimates. This leads to an attenuation bias of the mortality risk premium and underestimates it.

Furthermore, those who take risky jobs do not do so at random. They are not very risk averse, are more in need of income than most, or face unfavourable risk-income choices. Then, the wage risk premium of particular jobs is not representative for the risk preferences of the average individual in the economy. This biases the estimates of the mortality risk premium downward, since the average individual would be less inclined to take up risk and demand a higher price for it. The overall impact on the estimates is hard to predict. The lower bound from the subsection “Lower boundary for the value of a statistical life” gives an indication of how large a downward bias can at most be.

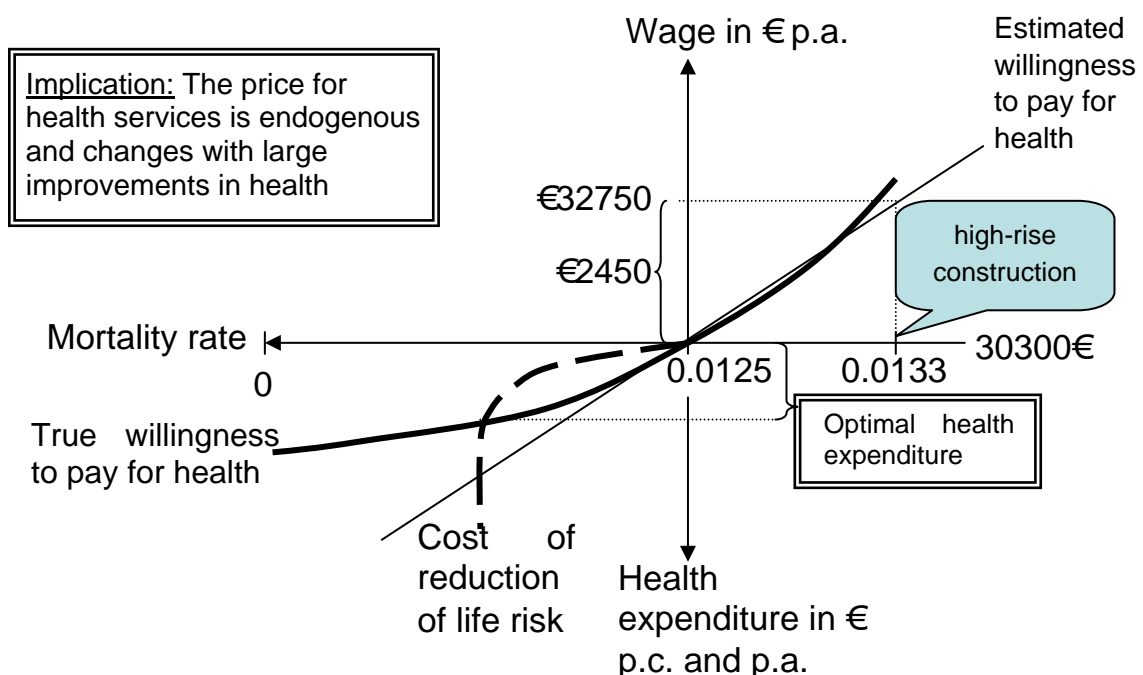
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31 We adjust the price the representative German is willing to pay for an additional year of life expectancy at birth by a 7.8% consumer price rise for Germany in between 2001 and 2006 (obtained from Statistisches Bundesamt) assuming health preferences to be homothetic.

## Optimal health expenditure

So far, we have determined the optimal willingness to pay for health goods and services per mortality rate reduction from the consumer optimisation problem. Hence, this characterises the demand for health goods and services. To close the model, we add the supply of health goods and services, which depends on the production function. A health-goods-and-service production function maps the labour input in the health sector into an average reduction in the mortality rate per year. We can show the equilibrium of the market for health goods and services in a simple diagram.

**Figure A 2: Optimal health expenditures**



P.a is per annum or per year; p.c. is per capita or per person.

Source: Authors

The vertical axis depicts annual income in euros. The value of €30,300 corresponds to the average income in the sample of Schaffner and Spengler (2005). The horizontal axis depicts the mortality rate. The value 0.0125 corresponds to average life expectancy. The value 0.0133 corresponds to the mortality rate of the riskiest profession in Germany: high-rise construction. Hence, a high-rise construction worker has a life expectancy of  $(1/0.0133 = 75.18)$  years compared to the assumed average of 80 years. For the five years lost in expected life expectancy, such a worker demands a life risk premium of 5 times the €490 or €2,450 in 2006 prices. For the benchmark estimate of the value of a statistical life year, this profession earns €2,450 per year extra for the work-related mortality risk. The slope of the straight line through the cross of vertical and horizontal axes and the locus for high-rise construction workers is the *estimated* willingness to pay for health services. The estimated one deviates from the true one, in particular, because it is by the nature of linear regression analysis a linear approximation on

the range of observations, i.e., on the range of the mortality rate from 0.0125 to 0.0133. The true willingness to pay for health goods and services is not linear. By the law of decreasing marginal utility, the representative agent demands disproportionately higher compensations for life risk increments the higher the life risk already is. Hence, the schedule of the true willingness to pay for health goods and services must be a convex curve through the intersection of the horizontal and vertical axes, and it must have an average slope identical to the estimated willingness to pay for health goods and services.

The first quadrant (the upper-right quadrant in the figure) thus far described concerns the market for work-related mortality risk. The willingness-to-pay-for-health-goods-and-services schedule also extends to the fourth quadrant (the upper-left quadrant). Then, the distances of a locus from 0.0125 on the horizontal axis describe the reduction of mortality risk per year through health goods and services. The difference between a locus on the vertical axis and €30,300 is the corresponding health expenditure per person and year.

Hence, the willingness-to-pay-for-health-goods-and-services schedule in the fourth quadrant characterizes the demand side of the health market. Note, however, that the true schedule is strictly above the estimated one. Hence, the estimated willingness to pay for health goods and services has an upward bias, because it does not take into account the convexity property of the true schedule. The bias will grow with the health improvement. As a consequence, the revelation principle is valid only for small improvements in the performance of the health system.

To obtain the optimal health expenditure, one needs to add the supply side. The supply side is just the cost function corresponding to the health production function. Its schedule maps to each (efficient) expenditure in health goods and services a corresponding reduction in the mortality rate per year. The intersection of the willingness-to-pay-for-health-goods-and-services schedule and the cost function for health goods and services determines the optimal level of health expenditure in this representative-agent economy.

Obtaining an assessment of how much additional health expenditure a representative German agent is willing to pay for health prevention measures depends thus on how effective they are in relation to the costs they cause. We need therefore to make an assessment of the cost function of prevention measures. This cost function must first assess the cost of a measure and second the expected reduction in the mortality rate. The cost assessment is quite difficult, though.

***Assessing the plausibility of the calculated optimal health expenditure:*** There is a simple way to determine whether our calculations make sense: Compare the calculated optimal health expenditure with the actual one. Assuming that the actual health expenditure is optimally chosen, it must not be statistically different from the calculated optimal health expenditure.<sup>32</sup> For the estimation period of the sample of Schaffner and Spengler (2005) that we took as the foundation for our calculations (i.e., for the period 1985–95, West German life expectancy rose from 74.8 to 76.5 years, according to OECD data). In the same period, health expenditure per capita in current prices rose from €1,416 to €2,331, according to the OECD, which corresponds to €2,086 and €2,733 in 2006 prices. Hence, a rise in life expectancy of 1.7 years during the sample period corresponds with a rise in health expenditure of €647, which is

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32 The following calculation assumes that the achieved improvement in life expectancy is a result of increased health expenditure. A proper causality analysis to investigate this assumption exceeds the scope of this study. Here, we limit our analysis to a simple consistency check.

amazingly close to the optimal health expenditure increase of 1.7 times €490, or €833.<sup>33</sup> This confirms that our approach yields reasonable values despite the large number of simplifying assumptions we made.

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<sup>33</sup> Of course, the two numbers are not statistically different.