European Commission

Comparative efficiency of health systems, corrected for selected lifestyle factors

Final report

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Abstract

The MACELI (Macro Cost Effectiveness corrected for Lifestyle) project studied the cost-effectiveness of European health systems, and the impact of differences in lifestyle, specifically smoking, overweight and alcohol consumption.

Baseline analyses without standardizing for lifestyle showed on average more health spending was associated with better health. This effect was clearest for countries with lower levels of spending. Standardization towards a better lifestyle meant an upward shift of the health production function, but did not much alter the comparative efficiency of countries.

The study covered the EU-28 Member States, Iceland, and Norway. Individual-level data were used to describe lifestyle across age and gender and to analyse its impact on health outcomes and health care use. Health outcomes and health spending were standardized for differences in lifestyle using a lifetable model (reference year 2010).

Results were put into further perspective by additional qualitative research and through several sensitivity analyses, including an indirect disease-based approach. Finally, a systematic literature review was performed to investigate potential interventions to achieve lifestyle changes.

Several shortcuts were taken to allow consistent estimates across a large number of countries, which imply that the results should be interpreted with care.

Key Terms: Health system efficiency; lifestyle; lifetable modeling

Management Summary

Introduction

Universal access to high quality health care while ensuring fiscal sustainability requires efficient health systems. Consequently, European countries measure and monitor the performance and cost-effectiveness of their health systems, partly supported by the European Commission. As documented in the European Commission's thematic summary report on health and health systems, various studies have suggested that health systems should be able to improve their efficiency (European Commission, 2014). In other words, better health outcomes may be in reach at current levels of resource use. However, the analyses need to be improved, for example by taking into account intrinsic differences in population conditions between countries (European Commission, 2014). The latter was the goal of the current study, which was conducted under the EU Health Programme.

As described in the tender call, the main objective was to gain insight into the efficiency of the health system in each country 'with the view to highlight the potential impact of changes in lifestyle habits'. In other words, we aimed to compare the cost-effectiveness of all European health systems while taking into account the variation in lifestyle behaviour between countries. The tender further specified a number of methodological choices. First, three lifestyle factors had to be studied: smoking, overweight and alcohol use. Second, a life-table approach was required, using public health modelling to correct for the effects of lifestyle factors. Third, a list of scenarios were to be included in the analyses. These scenarios specified changes in lifestyle prevalence to be applied to all countries for standardization purposes. Fourth, a literature review concerning the cost-effectiveness of lifestyle interventions was also required. The combining of all these elements would provide a better understanding of the impact of lifestyle on health outcomes and health spending at country level and how these healthier lifestyles might be achieved.

Methods

Conditional on data availability, the study was required to cover 31 countries: the EU-28 Member States and the EEA countries (Iceland, Norway and Liechtenstein). Liechtenstein was omitted from the analyses because of its small-scale health system, which also relies on a lot of cross boundary use, especially of more advanced care, in combination with a lack of data. International data sources were used, including individual-level survey data and national statistics obtained from WHO, OECD, Eurohex and Eurostat.

Previous studies have primarily used country-level summaries of lifestyle behaviour and included these as a confounder in their analyses of health system cost-effectiveness. In our analysis, we use individual-level data to describe lifestyle across age and gender and to analyse its impact on health outcomes and health care use. We standardized health outcomes and health spending for differences in lifestyle using scenarios, as specified in the tender requirements. In this way, we compared countries while assuming identical lifestyle prevalences at a detailed level. These detailed data also generated a more comprehensive understanding of the pathways through which lifestyle behaviour affects health system efficiency.

The approach taken was as follows. First, we investigated the relationship between health spending and population health at country level, without adjustment for differences in lifestyle between countries (baseline analysis). Second, the impact of lifestyle behaviour on health outcomes and health care use was estimated using individual-level survey data. We then estimated the impact of hypothetical changes in lifestyle behaviour using a range of scenarios, and a life-table approach (DYNAMO-HIA model), including the results from the second step. In this way, we were able to produce country-level estimates of health spending and population health that were standardized for lifestyle. Finally, the relationship between standardized health spending and standardized health outcomes at country level was compared with the baseline situation. The results were put into further perspective by additional qualitative research and through several sensitivity analyses, including an indirect disease-based approach. Finally, a systematic literature review was performed to investigate potential interventions to achieve lifestyle changes.

Results of quantitative analyses

The baseline analyses without standardization showed variation in health spending and health outcomes between countries. On average, more health spending was associated with better health. This effect was clearest for countries with lower levels of spending. The inclusion of confounding factors, especially Gross Domestic Product (GDP) per capita, substantially reduced the size of the correlation between health spending and population health. However, it was not possible to distinguish the impact of health spending and GDP with the data at hand.

The lifestyle data showed substantial variation in lifestyle habits between countries. In addition, the analyses showed a positive relationship between healthy lifestyles and health outcomes, in particular for smoking and BMI. With regard to alcohol use, health outcomes were best for moderate drinkers. Furthermore, a slightly positive relationship between unhealthy lifestyle and health care use was found. This was strongest for BMI, but overall less apparent than the relationship between a healthy lifestyle and health outcomes.

Hypothetical improvements in lifestyle behaviour, as specified in the scenarios, were associated with sizeable increases in healthy life expectancy across countries. For example, if all countries had the lifestyle prevalence of the countries with the most healthy lifestyles, then life expectancy would be higher, with increments varying from 0.4 to 3.1 years. In the extreme scenario, where all countries have a population with the most healthy lifestyle behaviour for overweight, smoking and alcohol use, the gain in life expectancy would vary from 2.5 to 5.7 years across countries. At the same time, the impact of changes in lifestyle on per capita health spending was limited when compared to the variation in health spending between countries. The strong association between health spending and GDP indicates that differences in wealth play an important role and may be more important than lifestyle in explaining cross-country health spending variation. Furthermore, cost-savings due to more favourable lifestyle patterns and the resulting lower disability prevalence in the different countries were partly outweighed by the additional health spending that results when people live longer (higher life expectancy) as a result of those more healthy lifestyles.

The overall effect of standardization towards a better lifestyle was an upward shift of the health production function. In other words, with a healthier lifestyle, higher healthy life expectancy could be achieved at country level for the same levels of health spending. A better outcome for approximately the same cost suggests an increase in overall efficiency. That is, a better lifestyle would result in a more efficient health system. However, this overlooks the fact that improvements in lifestyle are themselves reached at a cost and will take time. In practice, better lifestyle behaviour involves costs. However, the review also showed that cost-effective interventions to reduce unhealthy lifestyle do exist.

The results also suggested that the comparative efficiency of countries generally did not alter much by adjusting for current lifestyle differences. All countries seemed to move more or less in the same direction.

These main analyses were cross-sectional and thus cannot provide insight into the timelines of changes in lifestyle. In additional analyses we used models with explicit formalization of the causal chain from a healthier lifestyle through less lifestyle-related disease incidence, affecting prevalence, disability and mortality over time. These scenarios were performed for a single country (the Netherlands) and showed that the prevalence and costs of lifestyle-related diseases decreased first, followed by a decrease in mortality. Against a long-term 'steady-state' time horizon, this would lead to a population that is larger and older on average and to an increase in all diseases related to old age, which would then imply an increase in lifetime health care spending. The net effect depends on the lifestyles at stake, and on methodological choices such as the discount factor applied and the time horizon considered. For smoking, which is the most mortal lifestyle factor, the effects of increased longevity are strongest, followed by overweight and alcohol.

Results in perspective: qualitative aspects

In a qualitative analysis we investigated the role of other health system goals that were not included in this study, such as the equity and responsiveness of health systems. Countries with a relatively low level of overall population health given their level of health spending may have invested more in such non-health outcomes.

In addition, there are other confounders apart from lifestyle that affect the relationship between health spending and health. Income per capita is highly relevant. This implies that further research might be warranted, for example using more elaborate models enabling inclusion of the time dimension more explicitly. In particular, the recent economic crisis may provide new data with more variability in GDP and health spending trends, which may support an analysis of the role of these factors. In addition to providing insight into the effect of lifestyle on comparative efficiency, such research could support Member States in selecting the most efficient lifestyle policy for their specific circumstances.

Results in perspective: findings from comparable studies

Various previous studies used international aggregated data to analyse the relationship between health spending and population health across countries. Most of these studies focused on the average relationship between health spending and health outcomes. Some studies attributed part or all of the variation in health outcomes that could not be explained by health spending to the inefficiency of the health system. Generally, these studies aimed to control for confounders such as the socioeconomic characteristics of a country by including aggregate measures as explanatory variables in the analysis. Lifestyle characteristics at country level, for example the percentage of the population smoking, were also included as explanatory variables. Most studies showed a significant impact of lifestyle variables (smoking, alcohol and diet) on life expectancy, although the size of the impact was small in comparison to health spending, GDP and education. While previous studies included lifestyle behaviour as a confounder, they did not demonstrate the extent to which it affected the variation in health system efficiency.

In this study, socioeconomic characteristics, in particular GDP and education, were included in a similar way. The main difference between previous studies and the current study is the methodology used to standardize for lifestyle differences. We used a more sophisticated approach aiming to gain a clearer understanding of the different mechanisms through which lifestyle affects health system efficiency. Such a micro-level approach also allows for the measurement of various non-linear and interaction effects that may be at play in relation to lifestyle factors, in view of possible further data collection exercises. Measuring such effects via a macro-level regression approach would not appear straightforward, given unrealistic data requirements. We studied the impact of lifestyle on health spending and health outcomes separately, using individual-level data. These models included age, gender and country as confounding factors. These findings were subsequently included in a life-table model to investigate the impact of lifestyle changes on mortality and disability by age and gender. Furthermore, various standardization scenarios were tested in order to investigate multiple hypothetical changes in lifestyle behaviour. Finally, standardized measures of health spending and health were included in the efficiency analysis to determine whether lifestyle differences could explain efficiency variation among countries.

Results in perspective: options for a healthy lifestyle

To further put our results into perspective, it is relevant to compare lifestyle outcomes to current and potential policy efforts to achieve a healthy lifestyle across countries. Of course, these should be interpreted with due caution and considering the large impact of culture and history on each country’s lifestyle. There are policy scores for tobacco control and partly for alcohol policy. A similar estimate for overweight is recommended. When relating spending to the current prevalence of tobacco, clear differences in smoking prevalence can be seen between high spenders. These may reflect cultural differences or perhaps differences in policy choices.

Overall, it appears rather difficult at this stage to analyse the impact of spending on lifestyle-related prevention across countries. Comparable spending data by lifestyle factor are rare. Moreover, longitudinal data would be needed to analyse the true impact of lifestyle-related spending.

The results of the scenarios included in this study do provide an idea of the changes in mortality and disability that could be achieved if certain hypothetical changes in lifestyle occurred. Furthermore, the economic evaluations included in the literature review revealed that an effective lifestyle policy is, almost by definition, cost-effective due to the large potential health gains. However, by the very nature of prevention, the gains peak several years after initiation, as shown by the disease-specific scenarios. Policymakers need to have long time horizons to realize the gains from a more intensive lifestyle policy. Furthermore, they must realize that net health spending over the entire time horizon may actually increase as a result of an increased life expectancy in the population. In other words, a healthier lifestyle improves health outcomes but does not necessarily reduce costs. Most economic evaluations have traditionally been performed on individual-based interventions, while a number of evaluations regarding regulation, campaigns and tax policy have also been published.

Discussion of methods and results

Several shortcuts have been taken in this project to allow consistent estimates across a large number of countries. The additional country-specific analyses show that more in-depth methods can provide further insight, but also underline the large data requirements for such in-depth analyses. Our expert panels discussed drawbacks of our shortcuts and the need for further research. The options for more in-depth analyses grow as new and more comparable data rapidly become available. Important initiatives in this respect are the European Health Interview Survey (EHIS) and the System of Health Accounts (SHA).

In addition to aggregate statistics, our methods also require individual-level data. These provide more in-depth insight and enable the estimation of odds ratios linking lifestyles to health outcomes. These results raised most concern among the expert reviewers, especially the findings regarding alcohol. As self-report underestimates alcohol use, this may have biased our findings. We suggest further epidemiological research into the relationship between total exposure and damage for both overweight and alcohol. Furthermore, better registries distinguishing lifetime abstainers from former drinkers, and former smokers who are long-term quitters from short-term quitters, would also assist. However, this is quite a challenge for self-reported questionnaires.

The current analyses underline the fact that lifestyle is just one of a range of confounding factors in the relationship between total spending and health outcomes. Nevertheless, the analyses do reveal that lifestyle has a considerable effect on health benefits and will result in large gains. Hence, a fruitful direction for further research is to use the current approach and combine public health models with detailed information on health care spending to support Member States in making choices regarding prevention. The extension of the current additional analysis to more countries using disease-specific data would also be worthwhile. The methods and model structures are available, and projects such as the Australian ACE Prevention study and WHO CHOICE demonstrate the valuable insights that can be gained.

Policy implications

This project was a first attempt to provide broad insights that may assist in correcting health system efficiency for differences in lifestyle using individual-level data. The finding that a better lifestyle considerably improves health outcomes is not new, but it is worthwhile emphasizing once more. Both the main cross-sectional analyses and the additional dynamic and disease-specific analysis showed that scenarios with a healthier lifestyle lead to sizeable gains in the selected health outcomes; that is, healthy life expectancy.

The results with respect to health care spending show that changes which lead to a healthier lifestyle have both downward and upward effects on the demand for health care, with uncertain net effects. The results of the review regarding cost-effectiveness underline the potential value of investing in primary prevention.

Conclusions

Compared to previous studies, the current study enabled better insight into the different mechanisms through which lifestyle affects health system efficiency. Individual-level data analysis showed an effect of self-reported lifestyle behaviour on self-reported health. Furthermore, unhealthy lifestyles were associated with greater mortality risk, which was included in the DYNAMO-HIA simulations. Lifestyle directly affected health spending, which can be explained by the fact that people with unhealthier lifestyles use more care. There was also an indirect effect in the reverse direction: improved lifestyle behaviour generated a higher life expectancy, and longer lives implied greater age-related health care use.

The results showed that factors other than differences in lifestyle explain the majority of the variation in health spending between countries. Also, the differences in efficiency between countries did not change substantially after adjustment for lifestyle. Since we focused on the impact of a single confounder – lifestyle – the resulting differences in efficiency between countries should not be taken to constitute a definitive ranking of health systems.

Differences between countries in traditional lifestyle patterns could further complicate the picture. While the relationship between smoking history and current risk is well established, relatively little is known about the history of exposure and current risks for alcohol and BMI. This demands further epidemiological research and more extensive simulation modelling. Given the rather small effect of lifestyle standardization on the countries' relative efficiency in the current analysis, it does not seem very likely that an extensive analysis including all time lags in the proper way would reach different conclusions regarding the countries' comparative efficiency.

The scenarios ignored the costs and difficulties of achieving an improved lifestyle and this precludes any definitive statement of policy implications. However, our literature review underlines the fact that potentially cost-effective policy options are available and there is a clear potential for efficient prevention policy to improve health outcomes.

The study showed that hypothetical lifestyle changes generated higher healthy life expectancy at country level. At the same time, these changes had a limited impact on differences in health spending between countries. These outcomes were the result of a cross-sectional analysis without consideration of time lags, which should be kept in mind when interpreting them. Disease-specific scenarios for the Netherlands further clarified the mechanisms at stake, demonstrating that prevention does not necessarily result in lower acute care spending for all lifestyle factors, as a result of costs in life years gained. A healthier lifestyle in all scenarios improves health outcomes.

To conclude: the current cross-sectional results do not support the notion that the selected lifestyle factors of smoking, BMI and alcohol use are important confounders when establishing the comparative efficiency of the health systems of countries in Europe. No definite conclusions regarding the effects of more prevention on curative care spending can be drawn. However, the results support the view that substantial health gains can be achieved from a healthier lifestyle. As a result, the 'health production function' moves upward in hypothetical scenarios when all countries have a healthier lifestyle.

Résumé du rapport

Introduction

L'accès universel à des soins de grande qualité tout en assurant une viabilité budgétaire nécessite des systèmes de santé efficaces. C'est pourquoi les pays européens mesurent et surveillent les résultats et l'efficacité des coûts des systèmes de santé européens, soutenus en partie dans cette tâche par la Commission européenne. Ainsi qu'il en ressort des résumés thématiques de la Commission européenne portant sur la santé et les systèmes de santé, diverses études semblent indiquer que les systèmes de santé devraient être en mesure d'améliorer leur efficacité (Commission européenne, 2014). Autrement dit, de meilleurs résultats en matière de santé sont à portée de main avec les niveaux actuels d'utilisation de ressources. Cependant, les analyses doivent être améliorées en tenant par exemple compte des différences de conditions démographiques selon les pays (Commission européenne, 2014). Ce dernier point constituait l'objectif de la présente étude, qui fut menée dans le cadre du programme de santé de l'Union européenne.

Comme décrit dans l'appel d'offre, l'objectif principal consiste à mieux nous faire comprendre l'efficacité des coûts « afin de souligner l'impact potentiel des changements dans les mode de vie ». En d'autres mots, nous avions pour but de comparer l'efficacité des coûts de tous les systèmes de santé des pays européens en tenant compte des différences au niveau des modes de vie des différents pays. L'appel d'offre précisait ensuite plusieurs choix de méthodologie. Trois facteurs de risque devaient être étudiés : le tabagisme, le surpoids et la consommation d'alcool. Ensuite, il exigeait une analyse des tables de survie à l'aide des modélisations de santé de la population pour corriger les effets des facteurs de mode de vie. Troisièmement, l'appel incluait une liste de scénarios à inclure dans les analyses. Ces scénarios précisaient des changements au niveau de la prévalence de mode de vie à appliquer à tous les pays dans un souci de standardisation. Quatrièmement, il nécessitait une analyse documentaire de l'efficacité des coûts des interventions axées sur le mode de vie. Tous ces aspects contribuent conjointement à une meilleure compréhension de l'impact du mode de vie sur la santé et les dépenses de santé par pays et sur les méthodes à adopter pour parvenir à des modes de vie plus sains.

Méthodes

Sous réserve de la disponibilité de données, l'étude devait couvrir 31 pays ; les 28 États membres ainsi que les pays de l'EEE (Islande, Norvège et Liechtenstein). Le Liechtenstein n'a pas été pris en compte dans les analyses parce que son système de santé à petite échelle présente de nombreuses utilisations transfrontalières de soins médicaux, notamment des soins plus avancés, ainsi qu'en raison d'un manque de données. Des sources de données internationales disponibles ont été utilisées, y compris des données d'enquête au niveau individuel ainsi que des statistiques nationales provenant de l'OMS, de l'OCDE, d'Eurohex et d'Eurostat.

Les études précédentes utilisaient principalement des résumés à échelon national portant sur des modes de vie en les incluant comme facteur de confusion au sein des analyses de l'efficacité des coûts du système de santé. Dans notre analyse, nous avons utilisé des données au niveau individuel afin de décrire le mode de vie selon l'âge et le sexe et analyser son impact sur l'état de santé et l'utilisation de soins de santé. Nous avons standardisé les états de santé et les dépenses de santé pour les différents modes de vie à l'aide des scénarios spécifiés dans l'appel d'offre. Cela nous a permis de comparer les pays tout en assumant des prévalences identiques de modes de vie à un niveau détaillé. Ces données détaillées génèrent également une plus grande compréhension des mécanismes par lesquels les modes de vie influent sur l'efficacité du système de santé.

L'approche adoptée est la suivante. Nous avons tout d'abord étudié le lien entre les dépenses de santé et la santé de la population au niveau du pays sans procéder à aucun ajustement pour des différences de modes de vie entre pays (analyse préliminaire). Nous avons ensuite procédé à l'estimation de l'impact du mode de vie sur l'état de santé et l'utilisation des soins de santé à l'aide de données d'enquête au niveau individuel. Nous avons ensuite estimé l’impact de variations hypothétiques au niveau des modes de vie à l’aide d’une palette de scénarios. Pour cela, nous avons employé une approche par table de mortalité (modèle DYNAMO-EIS) en y incluant les résultats de la seconde étape. Cela nous a ainsi permis de produire, à l’échelon des pays, des estimations des dépenses de santé et de la santé de la population standardisées par mode de vie. Pour finir, nous avons comparé le lien entre les dépenses de santé standardisées et les états de santé standardisés à l’échelon du pays avec la situation de l’analyse préliminaire. Nous avons approfondi l’interprétation des résultats à l’aide d’une recherche qualitative supplémentaire et de plusieurs analyses de sensibilité, notamment une approche indirecte, basée sur la maladie. Pour finir, nous avons conduit une analyse documentaire systématique pour examiner les interventions susceptibles de parvenir à des changements de modes de vie.

Résultats d’analyses quantitatives

Les analyses préliminaires sans standardisation ont montré des différences au niveau des dépenses de santé et des états de santé selon les pays. En général, plus les dépenses de santé sont élevées, plus la santé est bonne. Cet effet est le plus évident dans le cas des pays présentant les plus bas niveaux de dépenses. La prise en compte de facteurs de confusion, notamment le produit intérieur brut (PIB) par habitant, a permis de réduire de manière substantielle l’ampleur de la corrélation entre les dépenses de santé et la santé de la population. Il n’a pas été possible de séparer clairement l’impact des dépenses de santé et le PIB sur la base des données disponibles.

Les données relatives au mode de vie ont montré d’importantes différences d’habitudes de vie entre les pays. Les analyses ont en outre montré l’effet positif d’un mode de vie sain sur l’état de santé, notamment pour ce qui est du tabagisme et de l’IMC. Pour ce qui est de l’alcool, les consommateurs modérés présentaient de meilleurs états de santé. En outre, un lien plutôt positif a été établi entre un mode de vie malsain et l’utilisation des soins de santé. Ce lien était le plus fort pour l’IMC mais, en général, moins prononcé que celui entre un mode de vie sain et un bon état de santé.

Les améliorations hypothétiques en matière de mode de vie spécifiées dans les scénarios étaient associées à une augmentation sensible de l’espérance de vie en bonne santé pour l’ensemble des pays. Par exemple, si tous les pays avaient eu la prévalence des modes de vie des pays ayant le mode de vie le plus sain, l’espérance de vie aurait été plus élevée avec des hausses entre 0,4 et 3,1 années. Dans le scénario extrême où tous les pays auraient eu une population présentant le mode de vie le plus sain en matière de surpoids, de tabagisme et de consommation d’alcool, l’augmentation de l’espérance de vie aurait pu varier de 2,5 à 5,7 ans dans tous les pays. En même temps, l’impact des changements au niveau du mode de vie sur les dépenses de santé par habitant était limité par rapport aux différences des dépenses de santé selon les pays. La forte corrélation entre les dépenses de santé et le PIB indique que les différences de richesse jouent un rôle important, peut-être même plus important que le mode de vie, pour expliquer les différences de dépenses de santé des pays. De plus, les économies générées par des styles de vie plus favorables et résultant en une prévalence moindre de l’incapacité dans les différents pays ont en partie été contrebalancées par les dépenses de santé supplémentaires liées à la plus grande espérance de vie des personne adoptant des modes de vie plus sains.

L’effet général de la standardisation vers un meilleur mode de vie fut synonyme de hausse de la valeur du capital-santé. En d’autres mots, avec un mode de vie plus sain et des dépenses de santé identiques, il serait possible de parvenir à une espérance de vie (en bonne santé) plus élevée. Un meilleur résultat pour un montant de dépenses semblables suggère une efficacité générale accrue. Cela signifie qu’un mode de vie meilleur résulterait en un système de santé plus efficace. Cependant, une telle conclusion revient à ignorer que les améliorations au niveau du mode de vie ont un coût et ne se font pas instantanément. Dans la pratique, un mode de vie meilleur implique des coûts. L’analyse a montré que des interventions rentables pour réduire les modes de vie malsains sont possibles.

Les résultats ont également suggéré que l'efficacité comparée de certains pays par rapport à d'autres ne variait en général pas beaucoup par l'ajustement des différents de mode de vie actuels. Tous les pays semblaient évoluer de manière plus ou moins similaire.

Ces principales analyses étant transversales, elles n'ont pas fourni d'explications quant aux délais des changements de modes de vie. Dans les analyses supplémentaires, nous avons utilisé des modèles avec modélisation explicite de causalité entre un mode de vie plus sain par le biais d'une incidence moindre de maladies liées au style de vie, affectant la prévalence, l'incapacité et la mortalité sur les changements dans le temps. Ces scénarios ont été appliqués pour un seul pays (les Pays-Bas) et ont illustré que ce sont d'abord la prévalence et les coûts de maladies liées au mode de vie qui baissent, suivie de la mortalité. En cas de modèle d'état stable, cela engendrerait une population plus importante et plus âgée en moyenne, ainsi qu'une hausse de toutes les maladies liées à l'âge, ce qui impliquerait par la suite une hausse des dépenses de santé sur une vie entière. Le résultat net dépend des modes de vie en jeu et des choix méthodologiques comme le facteur d'actualisation appliqué et la période prise en compte. C'est pour le tabagisme, facteur de mode de vie le plus mortel, que les effets sur une longévité accrue sont les plus tangibles, suivi par le surpoids et la consommation d'alcool.

Résultats en contexte, aspects qualitatifs

Dans une analyse qualitative, nous avons examiné le rôle d'autres objectifs de systèmes de santé qui ne faisaient pas partie de l'étude, comme l'équité et la réactivité des systèmes de santé. Les pays affichant une santé de population relativement faible malgré le niveau de leurs dépenses de santé ont peut-être investi davantage dans de tels objectifs non médicaux.

En outre, des facteurs de confusion additionnels existent au-delà du mode de vie et jouent sur l'efficacité des coûts sur la santé. Les revenus par habitant sont un facteur très important. Cela implique que des recherches supplémentaires pourraient s'avérer nécessaires, par exemple en utilisant des modèles plus élaborés permettant d'inclure plus explicitement la dimension temporelle. En particulier, la récente crise économique peut fournir de nouvelles données montrant des PIB plus variables et des tendances en matière de dépenses de santé justifiant l'analyse du rôle de ces facteurs. En plus d'améliorer la compréhension des effets du mode de vie sur l'efficacité comparée, de telles recherches pourraient aider les États membres à sélectionner la politique la plus efficace en matière de mode de vie dans leur contexte particulier.

Résultats en contexte, constatations issues d'études semblables

Plusieurs études précédentes se sont basées sur des données internationales agrégées afin d'analyser le lien entre les dépenses de santé et la santé des populations des différents pays. La plupart de ces études se sont intéressées au rapport moyen entre les dépenses de santé et les états de santé. Certaines études ont attribué la variation (ou une partie de celle-ci) des résultats de santé qui ne pouvant pas s'expliquer par les dépenses de santé à l'inefficacité des systèmes de santé. De façon générale, ces études avaient pour objectif de contrôler les facteurs de confusion comme les caractéristiques socio-économiques propres au pays en incluant dans l'analyse des mesures agrégées comme variable explicative. Les caractéristiques de mode de vie à l'échelon du pays, par exemple le taux de fumeur de la population, ont également été incluses comme variable explicative. La plupart des études ont montré un impact significatif des variables de mode de vie (tabagisme, consommation d'alcool et alimentation) sur l'espérance de vie, tout en soulignant que cet impact était faible comparé à celui des dépenses de santé, du PIB et du niveau de formation. Alors que les études précédentes incluaient les modes de vie en tant que facteur de confusion, elles n'ont pas permis de démontrer à quel degré celles-ci affectaient la variation au niveau de l'efficacité du système de santé.

Cette étude comprend de manière similaire des caractéristiques socio-économiques, notamment le PIB et le niveau de formation. La plus grande différence entre les études précédentes et l'étude actuelle est la méthodologie employée, qui consiste à standardiser les différences de mode de vie. Nous avons adopté une approche plus sophistiquée avec pour objectif une meilleure compréhension des différents mécanismes permettant au mode de vie d'influer sur l'efficacité du système de santé. En outre, une telle micro-approche permet de mesurer divers effets non linéaires et effets d'interaction entrant en jeu dans les facteurs de mode de vie, en prévision de collectes de données à venir. La mesure de tels effets par le biais d'une macro-approche de la régression semble compliquée, compte tenu d'exigences excessives relatives aux données. Nous avons étudié l'impact du mode de vie sur les dépenses de santé et les états de santé séparément à l'aide des données au niveau individuel. Ces modèles incluaient l'âge, le sexe et le pays comme facteurs de confusion. Ensuite, nous avons inclus ces constatations dans une table de survie pour étudier l'impact des changements de mode de vie sur la mortalité et l'incapacité selon l'âge et le sexe. En outre, plusieurs scénarios de standardisation ont été testés afin d'étudier des changements hypothétiques multiples au niveau des modes de vie. Pour finir, nous avons inclus les mesures standardisées des dépenses de santé et des états de santé dans l'analyse d'efficacité pour examiner si les différences au niveau des modes de vie pouvaient expliquer les variations selon les pays.

Résultats en contexte, options pour un mode de vie sain

Pour relativiser les résultats de notre étude, il convient de comparer les résultats de mode de vie aux efforts actuels et à venir des différents pays visant un mode de vie sain. Bien évidemment, il convient de faire preuve de prudence pour interpréter ces résultats et de prendre en compte l'impact important de la culture et de l'histoire sur le mode de vie des différents pays. Des chiffres sont disponibles pour les politiques de lutte contre le tabagisme et, dans une moindre mesure, pour les politiques de lutte contre l'alcoolisme. Il est recommandé de procéder à une estimation semblable pour le surpoids. Si l'on examine le lien entre les dépenses et la prévalence actuelle du tabagisme, on observe de nettes différences au niveau de la prévalence du tabagisme entre les pays où les dépenses sont élevées. Ces différences peuvent être le reflet de différences culturelles ou résultent probablement de différences de choix stratégiques.

Globalement, il s'avère difficile à ce stade d'analyser l'impact des dépenses en matière de prévention au niveau du mode de vie pour les différents pays. Il y a peu de données de dépenses comparables par facteur de mode de vie. En outre, il faudrait des données longitudinales pour analyser l'impact réel des dépenses liées au mode de vie.

Les résultats des scénarios inclus dans cette étude nous dévoilent les changements au niveau de la mortalité et de l'incapacité qui pourraient être réalisés si certains changements (hypothétiques) intervenaient au niveau du mode de vie. En outre, les évaluations économiques incluses dans la documentation montrent qu'une politique efficace en matière de mode de vie est presque par définition rentable en raison des importants gains sanitaires potentiels. Cependant, par la nature même de la prévention, les gains atteignent leur sommet au bout de quelques années, comme le montrent les scénarios spécifiques par maladie. Les décideurs politiques en la matière doivent penser sur le long terme pour réaliser des gains en adoptant une politique plus intensive en matière de mode de vie. En outre, ils doivent se rendre compte que les dépenses nettes de santé sur toute la période risquent d'augmenter en raison de la hausse de l'espérance de vie de la population. En effet, un mode de vie plus sain permet une amélioration des états de santé, mais ne signifie pas forcément des économies d'argent. La plupart des évaluations économiques ont généralement été effectuées sur des interventions individuelles ; plusieurs évaluations des politiques en matière de régulation, de campagnes et de taxation ont été publiées.

Discussion sur les méthodes et les résultats

Plusieurs raccourcis ont été pris au sein de ce projet pour nous permettre d'obtenir des estimations cohérentes pour un grand nombre de pays. Les analyses supplémentaires par pays montrent que des méthodes plus approfondies permettent une compréhension plus poussée, mais soulignent également la nécessité de données importantes pour mener à bien de telles analyses approfondies. Nos comités d'experts ont souligné ces raccourcis et formulé la nécessité de poursuivre les recherches. Les options possibles pour des analyses plus approfondies se multiplient au fur et à mesure que des données comparables plus nombreuses deviennent rapidement disponibles. Dans ce cadre, il convient de signaler des initiatives importantes, comme l'Enquête européenne de santé (*European Health Interview Survey*, EHIS) et le Système de comptes sur la santé (*System of Health Accounts*, SHA).

Nos méthodes nécessitent, en plus des statistiques agrégées, des données à un niveau individuel. Celles-ci nous fournissent une compréhension plus approfondie et permettent une estimation des *odds ratios* reliant modes de vie et états de santé. Cette partie de nos résultats, en particulier les constatations concernant l'alcool, a suscité des interrogations parmi les experts. Les déclarations volontaires entraînent une sous-estimation de la consommation d'alcool, ce qui a peut-être faussé nos constatations. Nous suggérons de poursuivre les recherches épidémiologiques pour ce qui est du surpoids et de la consommation d'alcool en examinant le lien entre exposition totale et dommages sur la santé. En outre, il convient de mieux distinguer les personnes n'ayant jamais bu d'alcool et les personnes ayant arrêté ainsi que les anciens fumeurs ayant arrêté de longue date et ceux ayant récemment arrêté. Sur la base de déclarations volontaires, cela constitue un défi certain !

Les analyses actuelles soulignent que le mode de vie est simplement un type de facteurs de confusion sur le lien entre les dépenses totales et les états de santé. Les analyses précisent que le mode de vie joue un rôle crucial sur les bienfaits sur la santé et entraînera des améliorations notables. Pour des recherches fructueuses à venir, il est donc conseillé d'adopter l'approche actuelle en l'associant à des modèles de santé des populations comprenant des informations détaillées sur les dépenses de santé afin d'aider les États membres à faire des choix en matière de prévention. Il serait très pertinent d'étendre l'analyse supplémentaire actuelle à plus de pays en utilisant des données relatives aux maladies. Les méthodes et les structures de modèles sont disponibles et les projets tels que « Australian ACE » et le projet OMS CHOICE nous offrent des perspectives précieuses.

Conséquences au niveau politique

Il s'agissait d'une première tentative visant à fournir des connaissances larges sur le lien entre l'efficacité du système de santé et les différences de mode de vie sur la base de données au niveau individuel. Constater qu'un meilleur mode de vie contribue à améliorer les états de santé n'a rien de nouveau. Il convient cependant de souligner une nouvelle fois cette constatation. Les deux types d'analyses, transversales d'une part et dynamiques et spécifiques à la maladie d'autre part, montrent qu'un mode de vie plus sain contribue à des améliorations considérables dans les états de santé sélectionnés : espérance de vie (en bonne santé).

Les résultats concernant les dépenses de santé montrent que les changements visant un mode de vie plus sain ont des effets positifs et négatifs sur la demande de soins de santé, engendrant des effets nets incertains. Les résultats de l'analyse de la rentabilité des coûts soulignent la valeur potentielle de l'investissement dans la prévention primaire.

Conclusions

Par rapport aux études précédentes, la présente étude nous a permis de mieux comprendre les différents mécanismes par lesquels le mode de vie influe sur l'efficacité du système de santé. L'analyse des données au niveau individuel a montré l'effet du mode de vie sur la santé, le tout basé sur des données de mode de vie et de santé autodéclararées.

En outre, les modes de vie malsains étaient associés à un risque de mortalité plus élevé qui a été inclus dans les simulations DYNAMO-EIS. Le mode de vie influait directement sur les dépenses de santé parce les gens ayant un mode de vie malsain utilisent plus de soins. Nous avons également noté un effet indirect allant dans la direction opposée. Un meilleur mode de vie engendre une espérance de vie plus longue, ce qui implique une augmentation de l'utilisation de soins de santé liés à l'âge.

Les résultats ont montré que des facteurs autres que les différences de mode de vie expliquaient la plupart des différences de dépenses de santé entre les pays. En outre, les différences d'efficacité entre les pays ne changeaient pas de manière significative après avoir modifié le mode de vie. Puisque nous nous sommes concentrés sur l'impact d'un seul facteur de confusion, le mode de vie, les différences d'efficacité entre les pays ne doivent pas être utilisées pour établir un classement définitif des différents systèmes de santé.

Les différences historiques entre pays au niveau des modes de vie risqueraient de compliquer encore plus le tableau. Alors que le lien entre les antécédents de tabagisme et le risque actuel est bien défini, on sait peu de chose sur les antécédents et le risque actuel en ce qui concerne l'alcool et le surpoids. Cela nécessiterait des recherches supplémentaires au niveau de l'épidémiologie ainsi qu'un modèle de simulation plus approfondi. Compte tenu de l'effet plutôt limité de la standardisation du mode de vie sur l'efficacité relative des pays dans la présente analyse, il semble cependant très peu probable qu'une analyse plus poussée, avec les périodes et délais voulus, pourrait mener à des conclusions différentes sur l'efficacité relative des pays.

Les scénarios ne tenaient pas compte des frais engagés et des difficultés rencontrées pour parvenir à un mode de vie amélioré. Cela empêche actuellement toute implication politique ferme. Notre analyse documentaire souligne que des options stratégiques rentables existent et souligne également le potentiel évident d'une politique efficace en matière de prévention pour améliorer la santé.

L'étude a montré que les changements hypothétiques en matière de mode de vie pouvaient générer une espérance de vie en bonne santé plus élevée à l'échelon du pays. En même temps, ces changements avaient un impact limité sur les différences en matière de dépenses de santé selon les pays. Ce sont des résultats découlant d'une analyse transversale qui ne tient pas compte de délais, ce qui convient de garder à l'esprit dans l'interprétation des résultats. Les scénarios de maladie pour les Pays-Bas ont permis de mieux expliquer les mécanismes en jeu en soulignant que la prévention n'implique pas forcément des dépenses de soins aigus plus faibles pour tous les facteurs de mode de vie ; en effet les frais peuvent augmenter en raison d'une augmentation des années vécues Dans tous les scénarios, un mode de vie plus sain améliorait les états de santé.

En conclusion : les résultats actuels (transversaux) ne corroborent pas l'idée selon laquelle les facteurs de mode de vie que sont le tabagisme, l'IMC et la consommation d'alcool sont un facteur de confusion important lorsqu'il s'agit de comparer l'efficacité des systèmes de santé en Europe. Aucune conclusion définitive ne saurait être tirée quant aux effets de dépenses accrues en matière de soins curatifs. Les résultats soulignent par contre que des améliorations sensibles de la santé peuvent être obtenues grâce à un mode de vie plus sain. Par conséquent, le « capital santé » augmente dans les scénarios hypothétiques selon lesquels tous les pays présenteraient un mode de vie plus sain.

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1. Introduction

Health expenditures have risen continuously in the past decades across all European countries. Health spending growth rates even outpaced national income growth and, consequently, comprise an increasing part of government and household budgets. On a European level, healthcare systems account for 8% of the workforce and 10% of GDP. Since a large part of its funding is from either general taxation or mandatory contributions to public insurance, the efficiency of the sector and its financial sustainability are relevant issues. Moreover, it has become increasingly important to improve the efficiency of European health systems in order to be able to ensure universal access to high quality care.

Against this backdrop, there is a need to improve the understanding of the efficiency of national health systems for European Union Member states and the European Commission, in cooperation with the Directorate-General for Health and Consumers (DG SANCO) (Council of the European Union, 2011; European Commission, 2014). Besides, DG Sanco aims to inform and support policy makers, stakeholders and citizens of European countries through information and knowledge about health system performance. Such empirical evidence should assist policy makers in analyzing, benchmarking and learning from best-practices in order to improve the cost-effectiveness of national health systems.

Measuring the efficiency of health systems is not easy for several reasons. Its output (health) is both multifactorial and hard to value in monetary terms. The inputs (health care spending) are but one factor that affects the output, next to a range of confounding factors, of which the most important are the general wealth of the population, environmental factors, lifestyle, and demographics. Additionally, the definitions and boundaries of health care systems may vary between countries (Arah et al., 2006). Finally, time plays an important role. Health outcomes may be affected both by current health care, but also by care in the past. Current spending will affect future health as well as current health. Similarly, past lifestyle behaviour may affect current levels of health and health spending. Hence, analyzing cross-country variation in health spending and the relationship between health spending and health outcomes (efficiency) is a complex undertaking.

Previous studies mostly used so-called health production functions representing the relationship between health outcomes and several input variables (determinants of health). These input variables included health spending, but also socioeconomic characteristics or lifestyle variables (see e.g. Nixon and Ulmann, 2006; Joumard et al., 2008 and Van Baal et al., 2013). Commonly, aggregate input measures and health outcome measures at country level were used. First, the production function determines the average relation between health spending and health while controlling for potential confounders. Second, it can be used to estimate the efficiency of individual countries. To that purpose, (part of) the variation in health outcomes that cannot be explained by input variables, is attributed to inefficiency. Though authors have aimed to tackle the issues mentioned in the previous paragraph, no study using country level data was able to address all methodological issues (Van Baal et al., 2013).

In this research project, the aim was to elaborate upon the impact of one particular input variable on health system efficiency, i.e. lifestyle behaviour. As stated in the Call for tender EAHC/2013/Health/05, 'Life Table Analysis: health system cost-effectiveness assessments across Europe', the main aim of this study is "… to provide a more complex analysis of cost-effectiveness of health systems that can allow the

European decision-makers to choose the correct strategic alternatives for the future of its health care systems, particularly regarding risks associated to lifestyle". More specifically the objective was to "carry out a health-system cost-effectiveness assessment in the EU-27 Member States, Croatia and the EEA countries (Iceland, Norway and Liechtenstein) with the view to highlight the potential impact of changes in lifestyle habits".

In particular, it focused on the impact of smoking, alcohol and overweight/obesity, which account for almost 15% of the burden of disease worldwide, 23% for the Western European region, or 29% for the Central European region (Lim et al., 2012, IHME 2014). *The main objective* was to compare the cost-effectiveness of European health systems while taking into account the variation in lifestyle conditions between countries. We used a more elaborate approach compared to previous studies, using individual level data to create better insight into the different mechanisms through which lifestyle affects health system efficiency. We studied the impact of lifestyle on health spending and health outcomes separately. Next, these findings were included in a life table model to investigate the impact of lifestyle changes by age and gender. Furthermore, various standardization scenarios were tested in order to investigate multiple hypothetical changes in lifestyle behaviour. In additional analyses, the effects of time lags were studied in more detail.

The report is structured as follows. Chapter 2 presents the study design and the main analytical steps that were taken. Chapter 3 presents intermediate results concerning the link between risk factors and health outcomes as well as health spending. Following, we present the main results in chapter 4. Chapters 5 and 6 provide additional results from a qualitative and lifestyle policy perspective. Chapter 7 contains discussion and conclusions.

2. Methods

The main objective of the study was to assess the average cost-effectiveness of 31 European health systems, while correcting for the impact of three lifestyle factors (tobacco, alcohol, and overweight) on both health spending and population health. This chapter gives a detailed overview of the methods used to reach this objective. Readers interested in the results could proceed directly to chapters 4 and further after having read the outline below describing the nine main steps of the study:

Step 1: Draft study design and review by experts.
A panel of experts received a detailed study design and a questionnaire asking for structured feedback. Their feedback was used in finalizing the study design.

Step 2: Health care efficiency without correction.
In the first part of the analysis, we analysed the relationship between health spending and population health at country level using scatter plots and regression analysis. We assessed countries' efficiency both parametrically by considering their distance from the regression line and non-parametrically by use of data envelopment analysis (DEA). In this step, we did not take into account differences in lifestyle behaviour between countries. Both cross-sectional and panel-data models were estimated.

Step 3: Information on lifestyle prevalence.
In the third step, we analysed the variation in lifestyle behaviour across the 31 countries, by age and sex, using individual level survey data. We focused on smoking, BMI and alcohol consumption. We collected cross-sectional lifestyle data for the most recent year available.

Step 4: impact of lifestyle on health and health spending.
We estimated the impact of each lifestyle variable on health outcomes and health spending. International individual-level survey data were used containing information on lifestyle, health outcomes and health care use. Odds ratios were estimated, representing the probability of higher/lower health spending or better/worse health outcomes for different categories of each lifestyle variable.

Step 5: standardizing health and health spending for lifestyle using scenarios.
In step 5, we analysed several scenarios representing hypothetical changes in the prevalence of lifestyle factors across countries. These lifestyle changes cause changes in health outcomes at country level and in health spending (defined as either total spending, or spending on curative care only). The DYNAMO-HIA (DYNamic MOdeling for Health Impact Assessment) lifetable model was used to estimate the impact of these hypothetical scenarios, in terms of the three measures of population health and the two health spending measures. The outcomes of step 3 and step 4 are used as input into the DYNAMO model, together with the observed mortality and health outcomes by country, age and sex.

Step 6: health care efficiency with correction.
Next, we used the results from step 5, i.e. the adjusted levels of health spending and population health at country level, to re-analyse the relationship between health spending and population health. Again, scatter plots and regression models were used to investigate the relationship between these two (adjusted) variables.

Step 7: inventory of policy options.

Additionally, we performed a literature review to gain insight into the (cost)-effectiveness of interventions aimed at lifestyle improvement. This review can provide lessons how to achieve lifestyle changes as hypothesized in the scenario analyses.

Step 8: Qualitative analyses and expert workshop.
To put our results into perspective we organised an expert workshop and consulted literature on definitions of health and health care systems. The results of this are described in the discussion sections

Step 9: Additional quantitative analyses.
For sensitivity analyses and to further understand the timing of the effects of lifestyle on health care spending and health outcomes, a full disease model was applied for the Netherlands.

Variables and countries
Health spending was defined in two ways: 1) including all health care and 2) including curative (health) care only. For the main results, the latter restricted definition was used, for three reasons. First, the objective of certain health services such as long-term care may not be to improve length of life. In that case, they will have a weaker relation to the summary measures of population health used. Second, definitions of long-term care show high variability across countries and their inclusion could result in less consistent estimates. Third, by restricting ourselves to curative care we ensure that costs of preventive care are excluded which makes it easier to interpret the results in the lifestyle scenarios. Throughout the study, 2010 was the main reference year. If necessary, costs were adjusted to the 2010 level using price indices. Three population health measures were used: life expectancy (LE), healthy life years (HLY, which refers to life expectancy without activity limitations) and life expectancy in good perceived health (LEGPH, which refers to life expectancy in at least good self-perceived health).
The study includes the EU-28 Member States and the EEA countries (Iceland, Norway and Liechtenstein). Table 2.1 shows the countries and their corresponding abbreviations. For most analyses, Liechtenstein and Luxembourg have been excluded, due to their small-scale health care systems, which include a limited set of health services only. Appendix 29.5 contains selected results for the EU-28 Member States.

2.1 Study design and expert consultation

A study design was drafted and summarized in a 10 pages document. This was sent to 10 experts, selected from a wide variety of expertise along with a structured comment sheet. The results were combined in an overview table, and used to summarize the main comments to SG Sanco. In consultation with DG Sanco, the design was finalized. The Appendix (Chapter 9.6, page 113 onwards) contains the design as provided to the reviewers, the questionnaire and a summary of their comments, as well as the list of experts consulted and their responses.

2.2 Health care efficiency without correction

Data and variables

Health spending
Data on health spending at macro-level were obtained from Eurostat, OECD and WHO, for the years 2004-2011. All three sources use the System of Health Accounts (SHA) definition of health expenditures (OECD, Eurostat, WHO, 2011). The SHA has been created to enhance the comparability of health spending data over time and across

countries. In case these sources reported different health expenditures for a specific country and year, we used the identical value reported by two of these sources.

We computed per capita health expenditures in Euros. The harmonized index of consumer prices (2005=100; Eurostat) was used to correct for inflation and calculate spending expressed at price level 2005 for all countries. Purchasing Power Parities for 2005 (EU28=1; Eurostat) were then used to correct for differences in price levels across countries.

Table 2.1: List of countries and abbreviations

Country	Eurostat abbreviation
Austria	AT
Belgium	BE
Bulgaria	BG
Croatia	HR
Cyprus	CY
Czech Republic	CZ
Denmark	DK
Estonia	EE
Finland	FI
France	FR
Germany	DE
Greece	EL
Hungary	HU
Iceland	IS
Ireland	IE
Italy	IT
Latvia	LV
Liechtenstein	LI
Lithuania	LT
Luxembourg	LU
Malta	MT
Netherlands	NL
Norway	NO
Poland	PL
Portugal	PT
Romania	RO
Slovakia	SK
Slovenia	SI
Spain	ES
Sweden	SE
United Kingdom	UK

Two different health spending measures were used: (1) total health expenditures and (2) expenditures on curative care. According to the SHA, total health expenditure is equal to "the sum of expenditure on activities that - through application of medical, paramedical, and nursing knowledge and technology – has the goals of:
- promoting health and preventing disease;
- curing illness and reducing premature mortality;
- caring for persons affected by chronic illness who require nursing care;
- caring for persons with health-related impairments, disability, and handicaps who require nursing care;
- assisting patients to die with dignity;
- providing and administering public health;
- providing and administering health programmes, health insurance and other funding arrangements" (OECD, Eurostat, WHO, 2011).

Curative care is defined as the sum of the SHA categories hospital care (HP.1), ambulatory care (HP.3) and outpatient medication (HP.4). These provider groups constitute around 80% of total health spending (on average across countries). Only the OECD and Eurostat provide detailed information on health spending by type of provider.

Table 2.2 presents the availability of data by country for both health expenditures measures between 2004 and 2011. For our base year (2010), data on total health spending were unavailable for Cyprus and Liechtenstein. In addition, information on curative care spending was also unavailable for Bulgaria, Croatia, Greece, Ireland, Italy, Latvia, Malta, and the UK. Proxy-values were estimated for these countries. Liechtenstein and Luxembourg have quite open health care systems, with a lot of cross boundary use of especially more advanced care. Furthermore, these two countries are quite small. For these reasons, they were excluded from the main analyses. Such exclusion criteria are necessarily arbitrary. One might e.g. argue that Malta and Cyprus would also qualify for exclusion. However, their isolated geography will reduce the amount of cross border care and hence we decided to keep them in.

Table 2.2: Data availability health spending per country over the period 2004-2011 (shaded cells indicate availability of data for entire period)

	Total health spending	Curative care spending	Source used[a]
Austria	2004-2011	2004-2011	Eurostat, OECD
Belgium	2004-2011	2004-2011	Eurostat, OECD
Bulgaria	2004-2011	2004-2008	Eurostat, WHO
Croatia	2004-2011	N.A.	WHO
Cyprus	2004-2010	2004-2008	Eurostat, WHO
Czech Republic	2004-2011	2004-2010	Eurostat, OECD, WHO
Denmark	2004-2011	2004-2010	Eurostat, OECD, WHO
Estonia	2004-2011	2004-2011	Eurostat, OECD, WHO
Finland	2004-2011	2004-2011	Eurostat,OECD
France	2004-2011	2004-2011	Eurostat,OECD
Germany	2004-2011	2004-2011	Eurostat, OECD, WHO
Greece	2004, 2009-2011	N.A.	OECD
Hungary	2004-2011	2004-2011	Eurostat,OECD
Iceland	2004-2011	2004-2010	Eurostat,OECD
Ireland	2004-2011	N.A.	OECD
Italy	2004-2011	N.A.	OECD
Lithuania	2004-2011	2004-2011	Eurostat, WHO
Latvia	2004-2011	2004-2009	Eurostat, WHO
Luxembourg	2004-2011	2004-2011	Eurostat, OECD, WHO
Malta	2004-2011	N.A.	WHO
Netherlands	2004-2011	2004-2011	Eurostat, OECD
Norway	2004-2011	2004-2010	Eurostat, OECD
Poland	2004-2011	2004-2011	Eurostat, OECD
Portugal	2004-2011	2004-2011	Eurostat, OECD
Romania	2004-2011	2004-2011	Eurostat, WHO
Slovenia	2004-2011	2004-2011	Eurostat, OECD
Slovakia	2004-2011	2005-2011	OECD, WHO
Spain	2004-2011	2004-2011	Eurostat,OECD
Sweden	2004-2011	2004-2011	Eurostat, OECD
United Kingdom	2004-2011	N.A.	OECD

[a] In case more than one source is reported, sources reported similar amounts of health spending (millions of National Currency Units).

Health outcome measures

In the macro-analysis without correction for lifestyle, we used three health outcome measures from the Eurostat databases: life expectancy at birth (LE), healthy life years at birth (HLY) and life expectancy in good perceived health at birth (LEGPH). We chose these outcomes since they are well defined and available in a consistent way in several questionnaires. The two quality of life outcomes rely on self-report and direct valuations of quality of life. QALYs and DALYs, two other well-known measures to include morbidity next to mortality in health outcomes do this slightly different. They value morbidity in terms of a 5 item questionnaire on daily activities or prevalent conditions respectively which are weighted using tariffs. The latter are based on population surveys and expert opinion. Since we knew that consistent information on disease prevalence or a dataset with both QALY values and lifestyle information would not be available, we preferred the self-reported outcomes. HLY is based on the GALI (General Activity Limitation Indicator) included in the EU-SILC survey (Statistics on Income and Living Conditions) and LEGPH is based on the variable good perceived health from the EU-SILC survey). The SILC data are published on the Eurohex website. Both health measures were available in the SHARE dataset, a large European dataset with lifestyle information.

Other variables used in the country-level regression models

While a whole range of potential confounders have been investigated, we decided to focus on a few important ones, for reasons of availability of consistent estimates for all countries and to keep the models as parsimonious as possible.
Thus, health outcomes were modelled as a function of health spending, adding national income and education to account for confounding. National income is measured by gross domestic product per capita (in 2005 international Euro's corrected using PPPs). Education is defined as the percentage of the population aged 25 years or older that has attained at least a higher secondary education degree. Information on both GDP per capita and education was obtained from the Eurostat website.

Analysis: health spending – health relationship

All analyses in this section were performed using Stata 13.

Cross-sectional models

First, we estimated the cross-sectional relationship between health spending and health for the reference year 2010, using the following ordinary least squares (OLS) model:

$$Y_i = \alpha + X_i\beta + \varepsilon_i \qquad (1)$$

with Y_i and X_i being a measure of population health and a matrix of explanatory variables in country *i*, respectively. Three measures of population health were distinguished: life expectancy at birth, healthy life expectancy at birth and life expectancy in good perceived health at birth. X_i consists of a measure of health spending (either total health spending or curative care spending), income and education. Using all combinations of the three population health measures and the two health spending measures resulted in six regression models.
All variables are logarithmically transformed to capture the diminishing marginal returns of health expenditures. As a result, the coefficients can be interpreted as elasticities.

Panel data models

Second, in line with the literature, we also estimated a panel model. Since data on health outcomes information in its current form (i.e. as estimated by the EU-SILC surveys) is only collected from 2004, regressions on a panel of countries over the period 2004-2011 have been used to measure the effect of health spending on health outcomes. Unlike the cross-sectional regression, the panel data regression can exploit variation over time t and between countries i:

$$Y_{i,t} = \alpha_t + X_{i,t}\beta + \varepsilon_{i,t}$$

$X_{i,t}$ includes a measure for health spending, GDP per capita and education. Country dummies (α_i) have been included representing time-invariant factors (e.g. institutional factors) that may influence the performance of health systems. At the same time, these fixed effects comprise all time-invariant or structural efficiency of health systems. As OLS residuals of the above equation were both heteroskedastic and serially correlated, the equation has instead been estimated by generalized least squares (GLS) with first order autoregressive and heteroskedastic error structure.
Note that this model cannot serve to compare health system cost-effectiveness before and after standardizing for lifestyle, because the standardization could be performed for one year of data only. Therefore, it was used as a robustness check to explore the extent to which the elasticity of health spending in the unadjusted model is sensitive to cross-sectional or panel data modelling.

Analysis: health system efficiency

To compare health system cost-effectiveness between countries, output-oriented technical efficiency scores were calculated. Output-oriented measures assess the possible improvement in population health that could be achieved by a country using the same amount of health spending with a similar socio-economic environment (the efficiency analyses also control for GDP per capita and education). Parametric and non-parametric approaches have been selected to assess relative efficiency of health systems in reaching the level of highest population health. As mentioned before, relative efficiency was analysed using cross-sectional data only.

Parametric method

Regression analyses can be used to assess relative performance by assuming that unexplained cross-country variation in population health reflects efficiency differences in the use of existing inputs.
First, A GLM regression with log link and gamma family has been used to assess the health production function. Population health is modelled as a function of health spending, GDP per capita and education (as in equation (1) above). A GLM regression has been selected to avoid the retransformation problem (see e.g. Manning and Mullahy, 2001). Second, efficiency (TE_i) is computed by

$$TE_i = Y_i - \hat{Y}_i$$

where Y_i is actual population health and $\hat{Y}_i$ is predicted population health using the GLM estimates. Hence, countries with a positive score perform on average better.

Non-Parametric method

The shape of the efficiency frontier constructed in the data envelopment analysis (DEA) depends on the choice regarding returns to scale. A variable returns to scale has been selected, allowing both increasing and decreasing returns to scale. Health spending, GDP per capita and education were included as inputs. Separate DEA were performed to assess efficiency in achieving each of the three health outcomes.

2.3 Information on lifestyle prevalence

Lifestyle

Our main data source was the Eurobarometer survey containing consistent questions on lifestyles across EU countries. The Eurobarometer data were available at the individual level. The lifestyle questions were not systematically included in all waves of the Eurobarometer survey. Therefore, reference years differed. For each of the lifestyle variables we used the most recent Eurobarometer data available: 2005 for BMI, 2009 for alcohol consumption and 2012 for smoking. For countries outside the EU before 2012, we had to rely on data from alternative (inter)national sources. Table 2.3 shows data availability for each of the three lifestyle variables used in this study, EB indicating available data from the Eurobarometer, "NS" indicating data were obtained from national sources and "GB" indicating only aggregate data from the WHO Global Burden of disease study were available.

For Iceland and Norway, alcohol data had to be imputed, based on summary data from the CAMH2012 report (Rehm et al. 2012), while overweight data could be obtained in more detail from the Global Burden of Disease Study. For smoking, data from the Norwegian Survey of Living Conditions held by Statistics Norway (aggregated data by age and sex) were used for Norway and Danish estimates were used as proxy for Iceland because national data were unavailable. Global Burden of Disease data were less suitable since these did not contain former smokers as a separate category. For Croatia, data for all lifestyle factors were available from the Croatian Adult Health Survey (individual level data could be used). Use of these different data sources implies that results for Iceland, Norway and Croatia may be less well comparable to the EU countries as regards lifestyle prevalence. Table 2.4 shows the categories we used for each of the three lifestyle variables.

The Eurobarometer data contained relatively few observations per country, while we needed estimates for each category, age and gender. Hence, data were pooled across all countries using country dummies to obtain prevalence estimates by country, gender and age using maximal power. In order to predict smoothed estimates, a multinomial 'vector generalized additive model' was applied, using the R package 'VGAM'. Several country specific dummies were included to allow flexibility in the location and shape of the relation between age and lifestyle. Likelihood ratio tests were applied to find the best smoothing parameter. However, these tests revealed a rather high value for smoothing, around 10 or 11. Upon visual inspection, a lower value of 6 was applied in all analyses to avoid too "bumpy" curves. Appendix 9.4 provides further details about the surveys and lifestyle data analysis.

Finally, the smoothed data were combined into a single dataset with age, gender and country specific percentages for a combined lifestyle variable containing 36 categories ranging from "never-smoker, healthy weight, not drinking" to "current smoker, obese, heavy drinker". This was done assuming independence between lifestyles.

Figure 2.1 to Figure 2.3: smoking in all countries show lifestyle prevalence at the aggregate level for each country as resulting from the smoothed data. The EU average was calculated by averaging over the smoothed data using country age and gender specific population sizes as weights.

Table 2.3: Data availability lifestyle variables per country

	Smoking	BMI	Alcohol
Austria	EB	EB	EB
Belgium	EB	EB	EB
Bulgaria	EB	EB	EB
Croatia	NS	NS	NS
Cyprus	EB	EB	EB
Czech Republic	EB	EB	EB
Denmark	EB	EB	EB
Estonia	EB	EB	EB
Finland	EB	EB	EB
France	EB	EB	EB
Germany	EB	EB	EB
Greece	EB	EB	EB
Hungary	EB	EB	EB
Iceland	GB	GB	CAMH
Ireland	EB	EB	EB
Italy	EB	EB	EB
Lithuania	EB	EB	EB
Latvia	EB	EB	EB
Malta	EB	EB	EB
Netherlands	EB	EB	EB
Norway	NS	NS	NS+GB
Poland	EB	EB	EB
Portugal	EB	EB	EB
Romania	EB	EB	EB
Slovenia	EB	EB	EB
Slovakia	EB	EB	EB
Spain	EB	EB	EB
Sweden	EB	EB	EB
United Kingdom	EB	EB	EB

Table 2.4: Lifestyle categories used in the study

Lifestyle	Categories
Smoking	1) Current smoker 2) Ex-smoker 3) Never smoked
Alcohol use (average daily consumption between brackets)	1) Current abstainer (0-0.025 gr/day) 2) Minor drinker (Males: 0.025-40 gr/day; Females: 0.025-20 gr/day) 3) Moderate drinker (Males: 40-60 gr/day; Females: 20-40 gr/day) 4) Heavy drinker (Males: >60 gr/day; Females: >40 gr/day)
BMI	1) Obese (BMI>30) 2) Overweight (BMI=>25 & BMI<=30) 3) Normal weight (BMI<25)

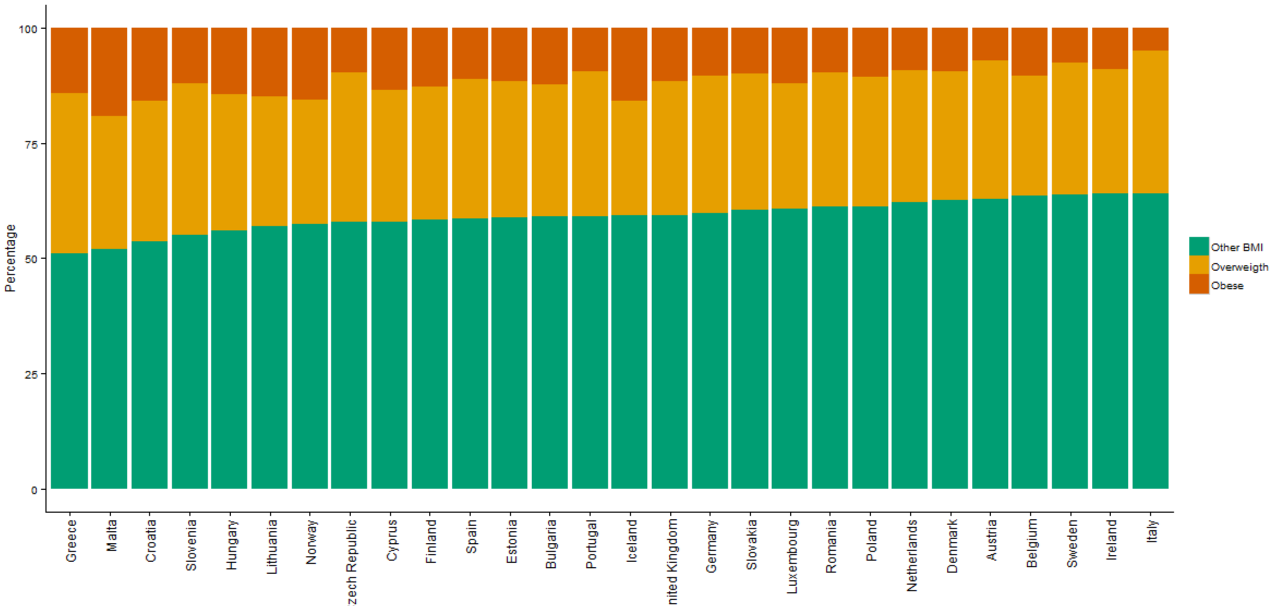

Figure 2.1: overweight in all countries

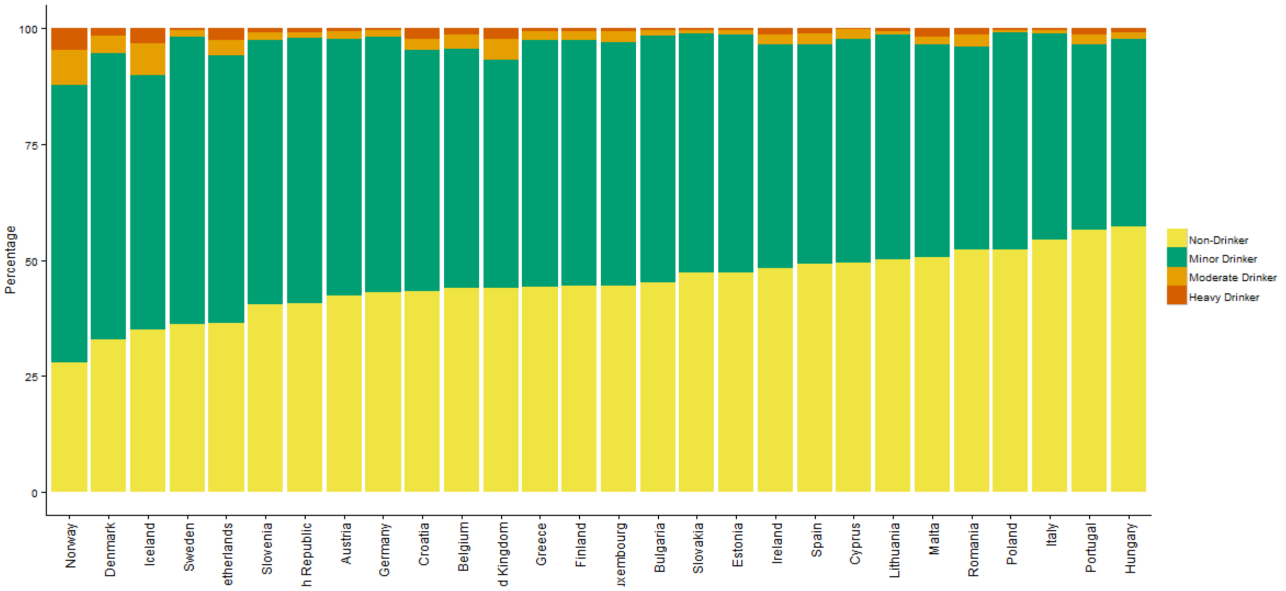

Figure 2.2: alcohol use in all countries

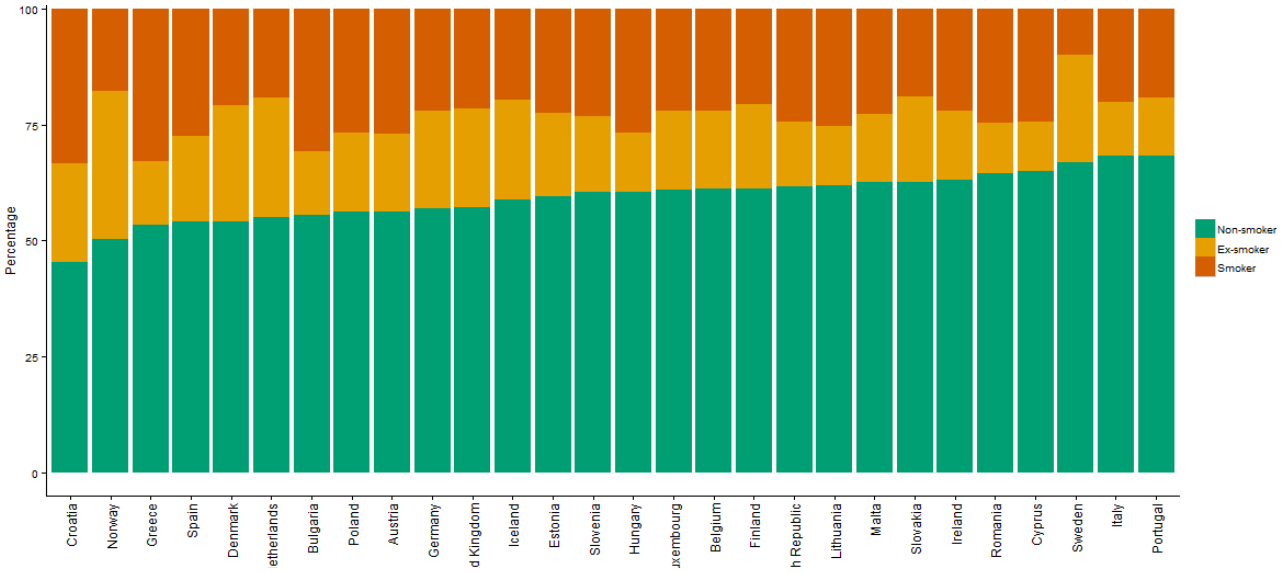

Figure 2.3: smoking in all countries

2.4 Impact of lifestyle on health outcomes and health care spending

The analyses in this section were performed in SPSS and Stata.

Odds Ratios 'lifestyle – health outcomes'

Odds ratios linking risk factor exposure to health outcomes (GALI and self-perceived health) were estimated using the European Survey of Health and Retirement (SHARE, www.share-project.org) for BMI and smoking behaviour, and the Enquête 'd'handicap et Santé" (HSM, www.insee.fr) data for drinking behavior. SHARE is an international longitudinal survey that covers a variety of European countries, including both Western and Eastern European countries. SHARE has collected detailed information on lifestyle, health, and health care use of individuals aged 50+ and their spouses. The odds ratios were calculated using wave 4 of the SHARE survey including the country samples listed in Table 2.5. We used the most recent wave 4, because certain lifestyle questions had been changed over time, creating incomparability between the different waves. The HSM is a French survey conducted between March and July 2008. The response rate was 76.6% corresponding to 29931 subjects. The questionnaire included questions on GALI limitations and self-perceived health, age and gender. 14,798 respondents aged 15 years and over also participated in the "auto questionnaire" which included detailed questions life style factors, including alcohol consumption, weight, lengths, and tobacco use.

Table 2.5: Countries included in odds ratio 'lifestyle - health outcomes' calculation

Country	Sample size
Austria	5,091
Belgium	5,098
Czech Republic	5,867
Denmark	2,203
Estonia	6,683
France	5,596
Germany	1,556
Hungary	2,987
Italy	3,510
Netherlands	2,716
Poland	1,708
Portugal	1,999
Spain	3,486
Slovenia	2,699
Sweden	1,943
Total	56,757

Odds ratios were estimated using logistic regression models. The two outcome measures, GALI and SPH, were split into two categories. For GALI we distinguished disabled (including both "limited" and "severely limited") and non-disabled. For SPH, we distinguished "good health (at least a good perceived health) and "no good perceived health" (remaining categories). Odds ratios were adjusted for age, sex, country and the other two lifestyle behaviours and were assumed constant over all countries and regions. For alcohol, only French data were used. The odds ratios for smoking behaviour and BMI were stratified by sex and age (50-65 and 65+), since both were a significant covariate. For alcohol, the models contained age as a continuous variable if the relation to age was significant.

For the age group <15 years, odds ratios were set to 1 and for the age group 15-50 years the odds ratios were assumed to be equal to those of the 50-65 years age group for smoking and overweight. Finally, all resulting odds ratios were checked for consistency and face validity by discussing results with project group members. They have also been presented as part of the interim report to the participants of the expert workshop. For alcohol, the initial SHARE analyses yielded very little contrast in odds ratios and hence the French data set was analysed in addition. The results from this dataset showed more consistency and face validity and were hence preferred over the SHARE results.

The odds ratios for all three lifestyle variables and categories were combined into 36 values representing all possible combinations of risk factor prevalences. To find odds ratios for these combined categories, the single category odds ratios were multiplied with each other.

We are aware that this is a simplifying assumption. However, it suits well to the way the odds ratios have been estimated (correcting for the remaining lifestyle factors). It is also the only way to use the currently available data, with separate sources for each of the lifestyle factors. Only when sufficiently consistent estimates of lifestyle prevalence at the individual level would be available for all countries and for each lifestyle simultaneously, other approaches would be suitable.

Odds Ratios 'lifestyle-health spending'

This section describes the data and methods used to estimate odds ratios for lifestyle and health variables. We used data from the SHARE survey to estimate these odds ratios. Here we included wave 1, 2 and 4 of the SHARE, to have maximal power. Respondents aged below 50 years (n=3395), permanent residents of LTC institutions (n=426) and respondents with incomplete information on variables of interest were excluded (n=5366). Table 2.6 presents the countries that are included in SHARE along with their sample size stratified by wave.

Table 2.6: Countries included in odds ratio 'lifestyle - health spending' calculation

Country	Wave 1	Wave 2	Wave 4	Total sample
Austria	1,494	1,128	4,852	7,474
Belgium	3,534	2,949	4,840	11,323
Czech Republic	0	2,592	5,608	8,200
Denmark	1,528	2,403	2,107	6,038
Estonia	0	0	6,416	6,416
France	2,852	2,689	5,264	10,805
Greece	2,608	2,944	0	5,552
Germany	2,863	2,417	1,475	6,755
Hungary	0	0	2,889	2,889
Ireland	0	1,062	0	1,062
Italy	2,402	2,833	3,378	8,613
Netherlands	2,716	2,452	2,538	7,706
Poland	0	2,358	1,488	3,846
Portugal	0	0	1,865	1,865
Spain	2,114	1,924	3,081	7,119
Slovenia	0	0	2,578	2,578
Sweden	2,904	2,596	1,829	7,329
Total	25,015	30,347	50,208	105,570

SHARE collects data on health care use, and not health spending. The following health care use variables were selected: hospital use, medical doctor (MD) visits, and medication use. These are exactly the three types of care that are represented in the curative care spending variable of the SHA (i.e. hospital care, ambulatory care and medication, see 2.2). Hospital care use is defined as being hospitalized in the 12 months preceding the interview. MD visits measures whether someone has visited a medical doctor in the 12 months preceding the interview. Medication use is defined by weekly medication use for at least one of the following conditions: high blood cholesterol, high blood pressure, coronary diseases, other heart disease, asthma, diabetes, joint pain, sleep problems, anxiety or depression, osteoporosis, stomach burns, chronic bronchitis.

2.5 Standardization

Standardization procedure

The DYNAMO-HIA model produced mortality probabilities, prevalence of self-rated health/disability by age, gender and country, as well as life expectancy and health expectancy (HLY, LEGHP) in various scenarios in which risk factor levels were varied. Health outcomes at population level were adjusted using the relative risks (for mortality) and odds ratios (for self-reported health and disability) that were associated with changes in lifestyle.

Lifetable model (DYNAMO-HIA)

We used the DYNAMO-HIA (DYNamic MOdeling for Health Impact Assessment) Model to calculate lifestyle standardized outcomes (www.dynamo-hia.eu; Boshuizen et al. 2012). DYNAMO-HIA is a modelling tool to quantify the health impact of lifestyle changes. The range of countries and many scenarios involved in our study make it more practical and less error-prone to use this dedicated software. DYNAMO-HIA includes checks of the input data (e.g. total prevalence of risk factor equals 100%) and has data storage capacities. The model was extended to allow for multiple risk factors so that in the scenario analyses all three risk factors could be changed simultaneously.

We ran DYNAMO-HIA with lifestyle risk factors directly linked to general health outcomes, in terms of mortality (relative risks) and disability (odds ratios). This avoids the use of less comparable and often unavailable country specific disease prevalence, incidence and mortality data, as well as disease and country specific cost data that will be impossible to obtain for all countries included.

The reference or baseline scenario was filled with data for 29 countries (excluding Liechtenstein and Luxembourg). This scenario reflects the current situation, that is, it represents countries' current lifestyle prevalence in relation to current health outcomes in terms of mortality and quality of life. Using odds ratios and relative risks, total mortality and quality of life were attributed to in total 36 different lifestyle categories, specific for age and gender.

Population

Data on population size by country, age and sex was obtained from the Eurohex website (www.eurohex.eu). In case the Eurohex population data were incomplete, data from the Human Mortality Database were added. In addition, for Croatia and Romania the highest age group was 85+ years. For these two countries, we estimated the age distribution of the 85+ population using the distribution of similar countries with regard to geographical location and life-expectancy, i.e. Slovenia (Croatia) and Hungary (Romania).

We averaged the population estimates of 2010 and 2011 for the mid-year population size of 2010. For countries with a population size lower than 2,000,000 (Cyprus, Malta, Estonia and Slovenia) the years 2009, 2010, 2011 and 2012 were averaged.

Mortality

Data on death counts were obtained from the Eurohex website, complemented with data from the Human Mortality Database (www.mortality.org) where necessary. Mortality by age and sex was calculated by dividing the death counts by mid-year population size of 2010. For the four small countries the death counts of 2010 and 2011 were averaged and divided by the average population sizes of 2009, 2010, 2011 and 2012.

Health status

For GALI, both “limited” and “severely limited” people were considered disabled and for self-perceived health we distinguished the groups “good health (at least a good perceived health) and “no good perceived health” (remaining categories). The Eurohex website published these data in 5-year age categories (from 16-19 years to 85+ years). The data were interpolated and smoothed by regression in combination with a smoothing spline, using the R package VGAM for categorical data analysis. The prevalence for 0 to 19 and 85 to 95 were set constant at their 19 and 85 year values.

Scenarios used in the standardization

Health outcomes were standardized using different scenarios. These scenarios describe hypothetical changes in the prevalence of lifestyle factors causing changes in health outcomes and health spending. In each of the scenarios, the prevalence of a certain lifestyle variable (e.g. BMI) is set to a certain value for each country, gender and age stratum. We used the following scenarios:

Scenario 0, “reference”
In the reference scenario, lifestyle prevalences were the smoothed observed data.

Scenario 1, “best of all”
In the first scenario, we apply the prevalence of the best-performing country to all other countries. A separate adjustment is made for each age group and gender. In other words, in each age-gender stratum a different country may be the best-performing country. ‘Best-performing’ in this case is equal to the highest prevalence in the most favorable category from a health perspective, i.e. the lowest prevalence of current-smokers, the highest prevalence of moderate drinkers and the highest prevalence of no overweight. By using a different reference category in each age-gender stratum, we assume that health behaviour and health policy can vary within countries.

Scenario 2
The second scenario consists of four variants. In the first variant, “positive all”, we set the prevalence of the most favorable category to 100% for all three lifestyle variables. In the other three variants, we applied the most favorable category of one of the three lifestyle variables to the entire population and used the observed prevalence for the other two lifestyle variables. This means that in the scenario 2a we set all the prevalence of moderate drinking to 100% and used the observed prevalence for each BMI-category and smoking-category. In scenario 2b we set BMI<25 to 100% for all countries and used the observed prevalence for each smoking-category and each alcohol use-category. In scenario 2c we set the prevalence of never-smokers to 100% and used the observed prevalence for alcohol use and BMI. These scenarios are called positive alcohol, positive weight and positive smoking, respectively.

Scenario 3
The third set of scenarios consisted of ‘negative’ changes in lifestyle behavior. In scenario 3, we set the prevalence of current smoking, obesity and no drinking to 100% for all populations. The other three variants showed one of the three lifestyle variables set to 100% in the most unhealthy category. This means that in the first scenario 3a we set all the prevalence of no drinking to 100% and used the observed prevalences for each BMI-category and smoking-category. In scenario 3b we set BMI>30 to 100% for all populations and used the observed prevalences for each smoking-category and each alcohol use-category. In scenario 3c we set the prevalence of current smokers to 100% and used the observed prevalences for alcohol use and BMI.

Scenario 4, “equal percentages”
In scenario 4, we set: 1) the prevalence of each smoking category (current smokers, never smokers and former smoker) to 1/3 of the population, 2) the prevalence of each BMI category (BMI<25, 25<BMI<30, BMI>30) to 1/3 of the population, and 3) the prevalence of each alcohol use category (abstainer, minor drinker, moderate drinker and heavy drinker) to 25% for all populations.

Scenario 5, “median health outcomes”
In scenario 5, we used health outcomes to adjust lifestyle prevalences. We selected the country with the median life expectancy at birth when averaging over men and women, i.e. Finland. The Finnish prevalences for each lifestyle variable were applied to all other countries.

Scenario 6 “median spending”
In the final scenario, we used health expenditure data to select a new reference country. Lifestyle prevalences of the country with median levels of health expenditures, Portugal, were chosen and applied to all other countries.

The table underneath summarizes the scenarios.

Table 2.7: Overview of scenarios. Assumptions regarding lifestyle prevalence

Scenario	Short name	Smoking	BMI	Alcohol
0	Reference	As observed	As observed	As observed
1	Best of all	Best performing country	Best performing country	Best performing country
2a	Positive all	100% healthy category	100% healthy category	100% healthy category
2b	Positive smoking	100% healthy category	As observed	As observed
2c	Positive bmi	As observed	100% healthy category	As observed
2d	Positive alcohol	As observed	As observed	100% healthy category
3a	Negative all	100% unhealthy category	100% unhealthy category	100% unhealthy category
3b	Negative smoking	100% healthy category	As observed	As observed
3c	Negative bmi	As observed	100% healthy category	As observed
3d	Negative alcohol	As observed	As observed	100% healthy category
4	Equal percentages	Equal division	Equal division	Equal division
5	Median health	Finnish prevalence	Finnish prevalence	Finnish prevalence
6	Median spending	Portuguese prevalence	Portuguese prevalence	Portuguese prevalence

Adjusting health spending

We first estimated health care use as a function of demographic, lifestyle and health variables and then used this function to estimate health care utilization in each of the hypothetical scenario's (see previous section for a description of the scenarios). The data contained three types of healthcare use: MD visits, medication and hospitalizations. The function for MD visits was used to adjust spending on ambulatory care; the function of medication to adjust spending on medical goods; the function of hospitalizations to adjust hospital spending.

Model specification

A pooled logistic regression model with standard errors clustered at the individual level has been used to estimate the association between demographics, lifestyle and health with health care use.

$$Y_{it} = \alpha + \beta_1 Age_{it} + \beta_2 Female_i + \beta_3 Age_{it} * Female_i + \beta_4 GALI_{it} + \beta_5 Age_{it} * GALI_{it} + \beta_6 SPH_{it} + \beta_7 Age_{it} * SPH_{it} + \beta_8 Country_i + \beta_9 Country_i * GALI_{it} + \beta_{10} Country_i * SPH_{it} + \beta_{11} Smoking_{it} + \beta_{12} BMI_{it} + \epsilon_{it}$$

Y_{it} is a measure of health care use (hospitalization, MD visits or medication use) for individual i at time t, using the SHARE data.

Given that health care use largely depends on the way the health care system is organized in a country, country dummies and an interaction between country and both health measures (GALI and SPH) were included as explanatory variables. This enables estimating country-specific OR's for GALI and SPH. Because alcohol consumption was not associated with health care use (only indirectly through health), it was not included as an explanatory variable. Lifestyle and health variables were defined as described in 2.3.

Several countries were not included in the SHARE survey. Therefore, it was impossible to obtain OR's for lifestyle/disability on health care use for all 29 countries with information on health spending in 2010. We therefore assumed that the OR's for the countries not represented in the SHARE survey are similar to those of neighbouring countries. Table 2.7 shows how the OR's of these countries have been approximated.

Using the above model specification, we computed an adjustment factor for each scenario and for each of the three types of care included in the SHARE survey. This adjustment factor consisted of two components. First, we calculated the probability of health care use for each country by multiplying: 1) the observed values at country level for the variables in the above model; with 2) the coefficients of the model as estimated from the SHARE data. Second, we computed the adjusted probability of health care use for each country by multiplying: 1) the adjusted values at country level for the variables in the above model; with 2) the coefficients of the model as estimated from the SHARE data. So *for each scenario, country and type of care* the adjustment factor was equal to the ratio of these two probabilities, i.e. one estimated using observed values and one estimated using adjusted values:

$$Adjustment\ factor = \frac{\text{Probability using care (covariates as in scenarios)}}{\text{Probability using care (covariates as observed)}}$$

Table 2.8: Approximate countries used

Country	OR based on:
Bulgaria	Hungary
Finland	Sweden
Croatia	Slovenia
Iceland	Sweden
Lithuania	Estonia
Luxembourg	Belgium
Latvia	Estonia
Malta	Italy
Norway	Sweden
Romania	Hungary
Slovakia	Czech Republic
United Kingdom	Ireland

The values of the lifestyle covariates in each scenario follow from the scenario definitions (e.g. positive all indicates that there are no smokers and no overweight and obese individuals). Furthermore, the percentage of disabled (GALI) and the percentage of individuals in less than good SPH (SPH) are taken from the DYNAMO output produced in each scenario (see 2.5). Hence, changes in lifestyle will both directly and indirectly (through disability and health) affect the level of health spending. Finally, DYNAMO's output for life expectancy was used to estimate the impact of age on healthcare use. As such, although improvements in lifestyle will improve overall health and disability they do not necessarily decrease health spending as older people use more health care. To compute the probabilities, female was set to 0.5.
The adjustment factors were multiplied with the actual spending for that type of service in 2010 (as registered in OECD and/or Eurostat). In other words, the adjustment factor for MD visits was used to adjust total expenditure on ambulatory care, the adjustment factor for medication was used to adjust total expenditure on medical goods, and the adjustment factor hospitalizations was used to adjust total expenditure on hospital care. Following the sum of the adjusted spending on ambulatory care, medical goods and hospital care generated total adjusted curative spending.

We assumed that changes in lifestyle would affect curative care spending only. For the 9 countries that did not have data on curative spending for 2010, we estimated these using data from other countries or earlier years. We found a strong association between GDP and the percentage of total spending allocated to curative care. As a result, the percentage of total spending allocated to curative care was estimated from countries with similar GDP levels in 2010. This approach was used for 6 countries; Croatia, Greece, Ireland, Italy, Malta and the UK. For Bulgaria, Cyprus and Latvia, data on curative care were available until 2008. We estimated the cost of curative care using the trend in total spending, which commonly follows a similar trend.

Table 2.9: *Approximate countries used*

Country	Reference country
Croatia	Estonia and Hungary (average)
Greece	Iceland and Portugal (average)
Ireland	Netherlands and Denmark
Italy	Spain
Malta	Iceland and Portugal (average)
UK	France and Spain (average)

2.6 Health care efficiency after correction for lifestyle

The model used to estimate standardized health system cost-effectiveness is similar to the models described in 2.2, but Yi and Xi now include a standardized measure for population health and health spending, respectively. Standardization methods were explained in section 2.5. The analyses were performed in Stata 13.

2.7 Review of policy options

The existing RIVM database on cost-effectiveness studies in prevention was extended with dedicated searches on tobacco, overweight and alcohol interventions in the TUFT database and the York database. In addition, the standard search strategy that is applied for the RIVM database was updated to 2013 to obtain the most recent studies. Studies were then selected on title and abstract on the following criteria: presenting a cost-effectiveness study for an intervention aiming at a healthy lifestyle concerning smoking, alcohol or overweight; being performed in a European country, to assure comparability regarding health care system and insurance habits; Original study, not a review or abstract only. Finally, the studies were classified according to the type of lifestyle intervention(s) evaluated.

Selection was performed by two independent researchers. Appendix 9.5 contains three tables with an overview of studies selected. The studies were then categorized regarding type of outcome measure (QALYs, LYG or another effect measure), setting, especially which country (EU or elsewhere) and type of intervention evaluated. A distinction was made between interventions targeting individuals, e.g. counselling to support weight reduction and policy interventions targeting groups of people, e.g. tax policy or smoking restrictions. Finally, for a selection of studies the results were extracted in more detail.

2.8 Qualitative analyses

An expert workshop was organized around the interim results, as resulting from steps 1 to 6. Care was taken to invite experts from a broad field of expertise, as well as an invited speaker applying an alternative approach to the issue of lifestyle and its effect on health system efficiency. The program of the workshop, a list of participants and summary of discussion points brought forward are given in the appendix (chapter 9.6). In addition, literature was consulted regarding health, health systems and the influence of lifestyle on health outcomes.

2.9 Understanding the dynamics resulting from lifestyle changes

To obtain better insight into how changes in lifestyle affect health outcomes over time, a number of scenarios was analysed in a dynamic lifetable model with explicit modelling of chronic diseases and their link to lifestyle factors. This was done using data from the Netherlands. The reference scenario, the “best of all” scenario and the “all positive scenario” were analysed in this disease specific model. Comparing the “best of all” or “all positive” scenario to the reference scenario shows how much is gained over time when all persons in a country change their lifestyle at baseline. Health care costs were calculated by multiplying disease prevalences with the annual costs per disease per patient (age and gender specific). Costs of all diseases not explicitly modelled were assumed to depend on age and gender while accounting for the fact that health care use is concentrated in the last year of life (van Baal et al. 2011a and 2011b).

Furthermore, for smoking, two extreme variants were compared in the “best of all scenario”. One variant assumed that all former smokers in the country had quitted smoking long ago, and thus had risks on disability and mortality equal to that of never smokers (former smoker is never smoker). The other variant assumed that former smokers had quitted only recently, and thus had the same relative risks as current smokers (former smoker is smoker). Both situations were standardized to the best-of-all country scenario, where -as before - former smokers have a relative risk that applies to a mixture of quitting durations. As such, the results give the maximum range of the impact of differences in time-effects from smoking. In all countries, however, the majority of former smokers are long-term quitters, so especially the former smoker is smoker scenario is rather unrealistic.

3 Intermediate results

Results regarding the effects of lifestyle on health outcomes and health care spending

3.1 Results analysis lifestyle – health outcomes

The relationship between lifestyle and health outcomes was estimated using data from the SHARE survey for BMI and smoking, and data from the Enquête 'd'handicap et Santé" (HSM) for alcohol consumption (see 5.1.4). Table 4.1 and Table 4.2 provide the odds ratios for different lifestyle categories and two health outcomes: the General Activity Limitation Indicator (GALI) and self-perceived health.

Table 3.1 shows that the probability of having activity limitations was higher for smokers and ex-smokers compared to non-smokers. Also, this probability was higher for those with overweight and obesity compared to respondents with normal weight. For females older than 65 years, we found a non-significant odds ratio for smoking of 0.92, implying a protective effect of smoking on disability (GALI). Since this finding is conflicting with literature and it was not significant we set this value to 1 in further analyses. The absence of increased risk of disability among smokers may reflect a "healthy smoker" effect, that is, smokers with smoking related diseases will be more inclined to quit smoking than smokers without such diseases. It may however also be a matter of data, with relatively low numbers of female older smokers and former smokers.

Table 3.1: Odds ratio's for GALI (limited or severely limited in activities) by gender and age group (95% CI between brackets)

Sex/ age	Male 50-64 (n=11693)	Male 65+ (n=11761)	Female 50-64 (n=14754)	Female 65+ (n=14696)
Smoker	1.80 (1.63-1.99)	1.28 (1.13-1.45)	1.14 (1.04-1.25)	0.92* (0.80-1.06)
Ex-smoker	1.56 (1.42-1.71)	1.07 (0.98-1.17)	1.07 (0.97-1.17)	1.09 (0.99-1.20)
Obesity	2.03 (1.82-2.26)	1.64 (1.46-1.85)	2.56 (2.32-2.82)	2.29 (2.07-2.54)
Overweight	1.33 (1.21-1.45)	1.11 (1.01-1.21)	1.33 (1.22-1.44)	1.24 (1.14-1.34)

* Set to 1

Table 3.2 demonstrates a more complex outcome for alcohol. The odds ratios do vary significantly with age for females, but not for men. For alcohol, "no consumption" is the reference category. No consumption, that is less than 0.25 g/day, appears as the unhealthiest category for men and older women. For young women, high consumption has large health risks. For men, the same trend was present but not significant. Part of the results will be due to a selection issue, because the category of no consumption probably contained a mixture of lifetime abstainers and former heavy drinkers.

Table 3.2: Odds ratio's for GALI (limited or severely limited in activities) by gender and for selected ages. ORs are available as a function of age.

Sex/ age	Male 20	Male 40	Male 60	Male 80	Female 20	Female 40	Female 60	Female 80
High alcohol consumption[1]	0.91	0.91	0.91	0.91	11.91*	1.32	0.63	1.31
Medium alcohol consumption[2]	0.55	0.55	0.55	0.55	0.26	0.48	0.71	0.83
Low alcohol consumption[3]	0.60	0.60	0.60	0.60	0.65	0.65	0.64	0. 64

* In the analyses this value was capped at 3 to avoid computational difficulties. Given the small size of the group and low prevalence of health problems that will only to a minor degree affect the results. 1 Male: >60g/day, Female: >40g/day; 2 Male: 40-60g/day, Female: 20-40g/day; 3 Male: 0.25-40 g/day, Female: 0.25-20 g/day

Table 3.13 and Table 3.14 show the results for self-perceived health. The table shows that for smoking and overweight, unhealthy lifestyles have larger odds ratios for "less than good" self-perceived health. These results are a bit more outspoken and consistent than for the GALI as a measure of health benefit. Age trends in odds ratios of alcohol are now significant in men and not in women. For alcohol, "no consumption" is the reference category. Hence ORs below one imply that the indicated category is more healthy than "no consumption".

Table 3.13: Odds ratio's for "Less than good" self-perceived health, by gender and age group (95% CI between brackets)

Sex/ age	Male 50-64 (n=11692)	Male 65+ (n=11758)	Female 50-64 (n=14756)	Female 65+ (n=14690)
Smoker	2.54 (2.29-2.81)	1.48 (1.30-1.68)	1.60 (1.45-1.76)	1.22 (1.06-1.40)
Ex-smoker	1.58 (1.44-1.74)	1.10 (1.00-1.08)	1.04 (0.94-1.15)	1.09 (0.99-1.07)
Obesity	2.06 (1.85-2.31)	2.33 (2.07-2.63)	3.17 (2.86-3.50)	2.27 (2.05-2.51)
Overweight	1.18 (1.07-1.29)	1.32 (1.20-1.44)	1.61 (1.47-1.76)	1.37 (1.26-1.48)

Table 3.14: Odds ratio's for "Less than good" self-perceived health by gender and for selected ages

Sex/ age	Male 20	Male 40	Male 60	Male 80	Female 20	Female 40	Female 60	Female 80
Heavy drinking[1]	1.26	0.83	0.54	0.35	0.95	0.95	0.95	0.95
Moderate alcohol consumption[2]	1.04	0.78	0.59	0.45	0.63	0.63	0.63	0.63
Minor alcohol consumption[3]	0.35	0.44	0.56	0.70	0.49	0.49	0.49	0.49

1 Male: >60g/day, Female: >40g/day; 2 Male: 40-60g/day, Female: 20-40g/day; Male: 0.25-40 g/day, Female: 0.25-20 g/day

3.2 Results analysis lifestyle – health spending

Table 3.25 presents the association between demographic, lifestyle and health variables and three types of health care use, i.e. visiting a medical doctor (MD) (column 2), taking weekly medication (column 3), or being hospitalized (column 4). These three groups (doctor visits, medication use and hospital care) represent a large part (around 80%) of total curative care spending.
The columns present the odds ratios (and corresponding confidence intervals) estimated with the regression model. The odds ratios represent the probability of health care use for the category shown, in relation to the probability of health care use for a reference group. For example, the odds ratio for MD visits was 1.04 for females, meaning that the odds of visiting a MD was 1.04 times higher for females than for males. The reference groups are mentioned in the table. For age, the interpretation is a bit different, each additional year implies a higher odds at the given size of using the specific type of care.
Most results are as expected. The probability of health care use was higher for older people and females. Regardless of the country, having a limitation or being in less than good self-perceived health increases the odds of an MD visit, medication use and a hospitalization. The ORs for both GALI and self-perceived health (SPH) are country-dependent as shown by the country-specific odds ratios.

Section 3.1 showed that lifestyle affects the probability of having activity limitations and self-perceived health. As a result, lifestyle will affect health care use and health spending *through* these two variables. On top of this, some risk factors also have an independent effect on health care use even after controlling for health status, as Table 3.25 shows. Individuals with overweight and in particular obese individuals, have a higher probability to visit the MD or use medication weekly. BMI does not have an independent effect on hospital care use. It turns out that ex-smokers have a higher probability of health care use compared to never smokers. At the same time, the probability of health care use was (surprisingly) lower for daily smokers compared to never smokers. Again, this might reflect the "healthy smoker" effect that was explained on page 39.

Table 3.25: Odds ratio's (95% CI) for health care use by self-reported health status

Variable		OR MD visit	OR medication	OR hospital
Age		1.04 (1.04-1.04)	1.07 (1.07-1.08)	1.03 (1.03-1.04)
Female		5.94 (4.42-7.98)	2.37 (1.81-3.09)	1.04 (0.81-1.34)
*Female*Age*		0.98 (0.97-0.98)	0.99 (0.99-1.00)	1.00 (0.99-1.00)
Smoking†				
	ex-smoker	1.18 (1.12-1.24)	1.28 (1.23-1.34)	1.27 (1.22-1.33)
	Smoker	0.66 (0.63-0.70)	0.96 (0.91-1.00)	0.98 (0.93-1.03)
BMI†				
	Overweight	1.27 (1.21-1.32)	1.56 (1.50-1.62)	0.92 (0.88- 0.96)
	Obese	1.33 (1.25-1.41)	2.42 (2.29-2.55)	1.00 (0.96-1.06)
*GALI*Age*		0.98 (0.98-0.99)	0.99 (0.99-0.99)	0.99 (0.98-0.99)
*SPH*Age*		0.99 (0.98-0.99)	0.99 (0.98-0.99)	0.99 (0.98-0.99)
GALI†				
	Austria	5.36 (3.59-7.99)	5.73 (4.17-7.87)	4.80 (3.44-6.72)
	Germany	9.08 (4.45-18.55)	4.74 (2.83-7.96)	5.72 (3.29-9.95)
	Sweden	7.32 (3.89-13.77)	5.21 (3.14-8.66)	6.83 (3.96-11.80)
	Netherlands	7.35 (3.90-13.83)	3.92 (2.37-6.46)	5.32 (2.98-9.47)
	Spain	6.69 (3.35-13.38)	6.47 (3.72-11.25)	6.04 (3.43-10.64)
	Italy	6.92 (3.56-13.46)	4.67 (2.78-7.82)	6.95 (4.02-12.02)

France	6.50 (3.25-13.00)	4.05 (2.44-6.72)	4.85 (2.88-8.18)
Denmark	6.03 (3.09-11.73)	4.49 (2.65-7.60)	6.06 (3.40-10.81)
Greece	6.92 (3.44-13.94)	6.20 (3.41-11.28)	7.38 (3.97-13.71)
Belgium	7.50 (3.81-14.74)	4.23 (2.56-6.98)	6.00 (3.57-10.08)
Czech Republic	8.14 (4.14-16.00)	7.96 (4.78-13.27)	5.33 (3.09-9.19)
Poland	7.37 (3.71-14.61)	6.66 (3.82-11.63)	5.49 (3.01-10.01)
Ireland	20.59 (6.21-68.32)	6.38 (3.08-13.21)	8.83 (4.08-19.13)
Hungary	6.76 (3.26-14.02)	9.20 (5.03-16.81)	6.19 (3.28-11.69)
Portugal	6.36 (2.80-14.44)	5.97 (3.09-11.53)	7.13 (3.39-15.03)
Slovenia	6.17 (3.00-12.70)	5.29 (2.97-9.45)	6.13 (3.22-11.68)
Estonia	7.09 (3.75-13.40)	6.44 (3.85-10.76)	6.90 (3.88-12.27)
SPH†			
Austria	3.32 (2.13-5.17)	7.63 (5.22-11.15)	4.57 (3.35-6.25)
Germany	4.94 (2.16-11.29)	8.58 (4.54-16.21)	5.26 (3.14-8.82)
Sweden	4.18 (2.00-8.73)	7.25 (3.79-13.86)	4.48 (2.68-7.49)
Netherlands	5.34 (2.53-11.26)	9.97 (5.29-18.79)	6.67 (3.92-11.35)
Spain	5.37 (2.52- 11.45)	8.60 (4.54-16.29)	5.01 (2.90-8.64)
Italy	4.74 (2.28-9.88)	6.01 (3.24-11.14)	4.55 (2.71-7.64)
France	4.71 (2.16-10.25)	7.77 (4.16-14.51)	5.02 (3.06-8.23)
Denmark	3.86 (1.78-8.34)	7.34 (3.78-14.26)	)4.82 (2.79-8.36)
Greece	4.72 (2.18-10.21)	7.19 (3.63-14.27)	5.08 (2.81-9.18)
Belgium	6.09 (2.70-13.75)	7.34 (3.88-13.88)	4.13 (2.53-6.74)
Czech Republic	3.67 (1.71-7.87)	5.38 (2.88-10.07)	4.32 (2.62-7.13)
Poland	3.81 (1.79-8.08)	5.95 (3.11-11.37)	4.49 (2.52-7.99)
Ireland	7.31 (1.93-27.67)	7.45 (2.97-18.67)	3.98 (1.86-8.50)
Hungary	3.16 (1.43-6.95)	5.79 (2.94-11.41)	4.50 (2.43-8.34)
Portugal	4.07 (1.74-9.52)	6.20 (3.04-12.66)	3.39 (1.62-7.12)
Slovenia	3.37 (1.53-7.41)	4.80 (2.45-9.43)	3.41 (1.87-6.24)
Estonia	3.25 (1.60-6.62)	6.73 (3.64-12.44)	4.18 (2.34-7.44)
Country†			
Germany	1.34 (1.15-1.56)	0.91 (0.81-1.02)	0.53 (0.45-0.62)
Sweden	0.46 (0.40-0.52)	0.90 (0.81-1.01)	0.42 (0.36-0.49)
Netherlands	0.51 (0.45-0.58)	0.75 (0.67-0.84)	0.29 (0.25-0.35)
Spain	0.96 (0.84-1.10)	1.18 (1.06-1.31)	0.33 (0.27-0.39)
Italy	0.81 (0.71-0.92)	1.23 (1.11-1.36)	0.39 (0.33-0.46)
France	2.05 (1.79-2.35)	1.65 (1.50-1.82)	0.57 (0.49-0.65)
Denmark	0.75 (0.66-0.85)	0.95 (0.85-1.06)	0.45 (0.38-0.53)
Greece	0.58 (0.51-0.66)	1.49 (1.33-1.66)	0.26 (0.21-0.32)
Belgium	1.58 (1.39-1.80)	1.85 (1.67-2.04)	0.61 (0.54-0.70)
Czech Republic	1.24 (1.08-1.42)	1.09 (0.98-1.21)	0.56 (0.47-0.66)
Poland	0.42 (0.36-0.49)	0.72 (0.62-0.84)	0.51 (0.40-0.65)
Ireland	0.68 (0.55-0.83)	0.86 (0.73-1.03)	0.52 (0.39-0.70)
Hungary	0.67 (0.56-0.81)	0.91 (0.78-1.06)	0.47 (0.36-0.61)
Portugal	0.81 (0.65-1.01)	1.23 (1.03-1.47)	0.30 (0.21-0.44)
Slovenia	0.60 (0.51-0.71)	0.91 (0.79-1.05)	0.45 (0.35-0.58)
Estonia	0.42 (0.36-0.48)	0.49 (0.43-0.56)	0.31 (0.24-0.39)
Constant	0.33 (0.26-0.44)	0.01 (0.01-0.01)	0.02 (0.01-0.03)

†Smoking: reference category = never smoker;
BMI: reference category = BMI<25;
GALI odds ratio: numerator = activity limitations, denominator/references=not limited;
SPH odds ratio: numerator = less than good perceived health; denominator/reference= good SPH;
Country: reference category = Austria.

4 Results of quantitative analyses

4.1 Health system cost-effectiveness unadjusted for lifestyle

This section presents the cost-effectiveness of health systems *before* filtering out the variation in lifestyles between countries. Therefore, estimating the relationship between health spending and health outcomes is at the core of this section. This section presents the findings for curative care spending only. The conclusions from the analysis with total health spending are virtually identical (see Appendix 9.1). Appendix 9.7 contains the results for the EU-28 member states.

The analyses in this paragraph are based on country-level data obtained from OECD, Eurostat and WHO. These include health spending and population health variables as explained in the previous chapters. Furthermore, variables on education (percentage of population 25 years and older with at least secondary education) and national income (GDP per capita) were added to the analyses. All figures present per capita health expenditures in Euros, price level 2011. Purchasing Power Parities (EU28=1; Eurostat) were used to correct for differences in price levels across countries. More details on data and methods can be found in Chapter 2.

Graphical presentation of the association between health spending and population health

Figure 4.1 to Figure 4.3 presents the association between curative care spending and population health for the year 2010. The level of curative care spending ranged between around € 400 per capita in Romania and around € 2800 per capita in Norway. Population health varied as well. Life expectancy at birth ranged between almost 73 years in Lithuania and over 82 years in Spain, for both sexes combined.

Regardless of the population health measure, curative care spending and population health were positively associated. A comparison of goodness of fit measures (i.e. R-squared) between an OLS model with raw variables and logarithmically transformed variables, revealed that the association could best be described as one with diminishing marginal returns of curative care spending on population health. The variation in curative care spending could explain over 50 percent of the variation in life expectancy or life expectancy in good perceived health, but only 19 percent of the variation in healthy life years.

The figure also presents the elasticity[1] of curative care spending obtained from an OLS model with all variables logarithmically transformed, showing a significantly positive association between curative care spending and population health (the elasticity is equal to coefficient of health spending in the regression model). The association is stronger for the two population health measures that take into account quality of life next to length of life. A 1 percent increase of curative care spending is associated with a 0.057, 0.066, and 0.094 percent increase in life expectancy, healthy life years and life expectancy in good perceived health, respectively.
Total health spending also has a clear, but weaker, relationship with all three population health measures (see Chapter 9.1). This is not surprising given that total health spending also includes spending categories that do not directly aim to improve life expectancy (i.e. administrative costs, long-term care spending).

[1] Elasticity = the percentage change in population health (LE, HLY, LEGPH) associated with a 1% change in health spending.

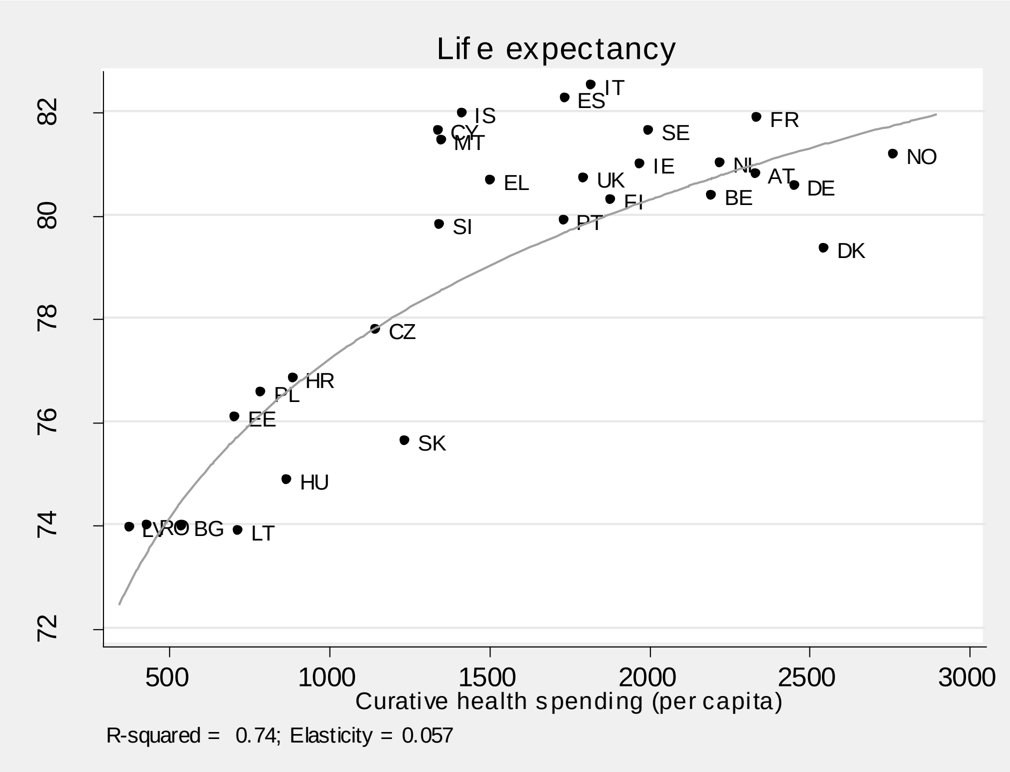

Figure 4.1: The association between curative care spending and life expectancy

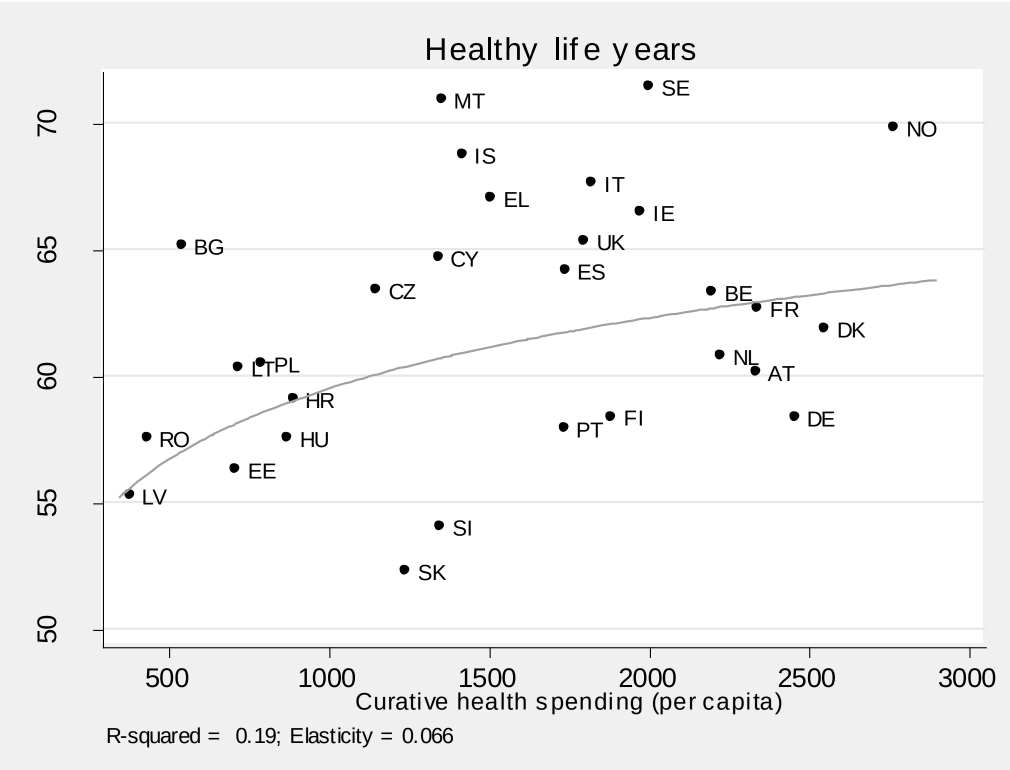

Figure 4.2: The association between curative care spending and healthy life years

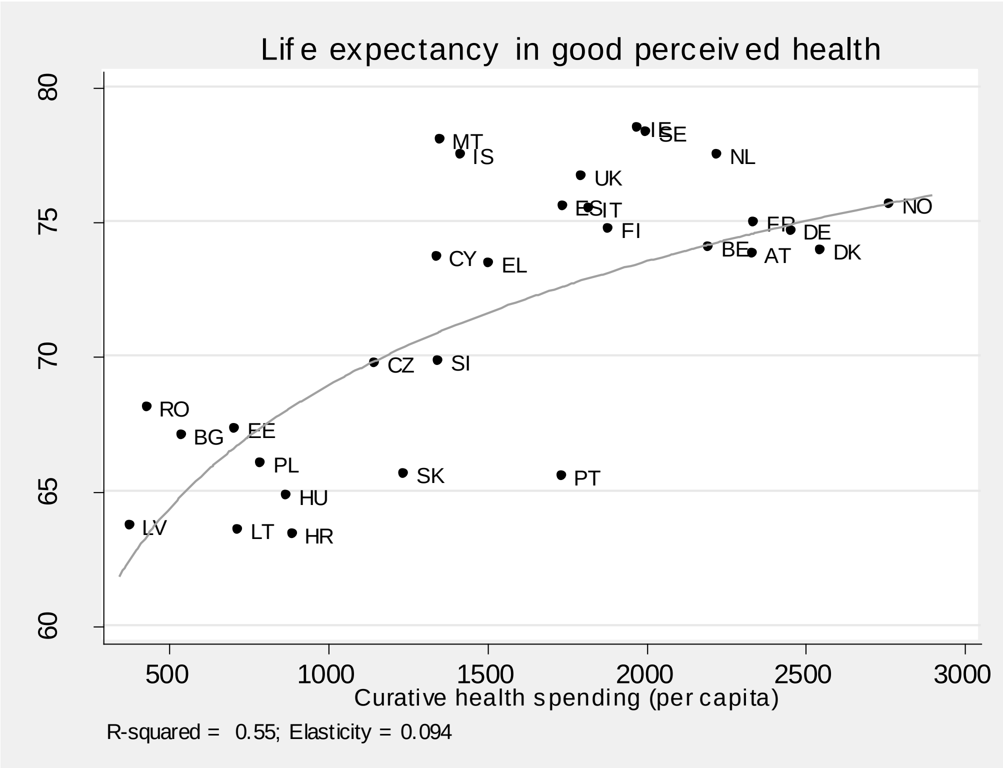

Figure 4.3: The association between curative care spending and life expectancy in good perceived health

The effect of health spending on population health

This subsection provides a more thorough analysis of the relationship between curative care spending and population health.

Table 4.1 below shows that after controlling for additional variables, i.e. GDP per capita and education, curative care spending is only positively associated with life expectancy. The absence of a significant and positive effect of curative care spending on HLY and LEGPH is related to the high correlation between curative care spending and GDP per capita (ρ=0.93). Figure 4.1 already showed that richer western European countries have higher levels of health spending and population health. It means that it is difficult to separate out and estimate the true effects of GDP per capita and curative care spending on population health. Moreover, both curative care spending and GDP per capita may also be affected by population health (issue of endogeneity) (Gravelle and Backhouse, 1987). The results of the basic model in Table 4.1 are robust for the selection of the year (2004-2011).

Table 4.1 also presents the effect of health spending, GDP per capita and education as estimated by a panel data model. Note that the panel analyses were used to increase the reliability of the estimates of the basic model and not to investigate the lagged impact of health spending on health. The direction of the effect of health spending is similar to the one estimated by the basic model. However, health spending now has a significant effect on all three population health outcomes. Curative care spending positively affects LE(GPH), but has a negative effect on HLY. Overall, it appears that using HLY as outcome measure gives different results in comparison to LE and LEGPH. Figure 4.1 also showed a much lower R-squared for the HLY-variable. These differences require further exploration before reaching conclusions. The same holds true for the negative impact of GDP per capita on health as estimated in the panel data model. A major problem in all these analyses is the large correlation between the different explanatory variables. Education and curative care spending both rise with an increasing GDP and show relatively little variation among the European countries, if compared to the variance observed worldwide. More advanced data analyses would be advisable, applied to a larger dataset. A longer period of panel data would allow to include lagged variables.

Table 4.1: Elasticity of population health to curative care spending, GDP per capita and education

	LE	HLY	LEGPH
Basic model (2010)			
Curative care spending	0.055***	-0.076	0.053
GDP per capita	0.000	0.180	0.055
Education	-0.022	-0.031	0.018
N	21	21	21
R-squared	0.76	0.30	0.58
Panel data model (2004-2011)			
Curative care spending	0.031***	-0.174***	0.103***
GDP per capita	-0.022**	0.097**	-0.059***
Education	0.131***	0.311**	0.252***
N	179	164	164

P-value of null hypothesis of no effect. *p<0.10; **p<0.05; ***p<0.01

Technical efficiency of health systems

A simple way of measuring the efficiency of health systems is to first estimate the relationship between health spending and population health (using the basic model in Table 4.1) and then to compare the actual absolute values of population health with their fitted (predicted) values. The log-transformation is chosen as health care is most likely subject to diminishing returns, i.e. it could be quite costly to further improve population health if population health of a country is already quite high. Hence, a country’s relative performance is measured as the distance between the actual and fitted values of population health in comparison to that distance for the other countries.

Figure 4.4 presents the efficiency measures described above for each country for all three population health measures, for the year 2010. That is, it shows the differences between the observed and predicted levels of population health. The figure clearly shows that a country’s performance depends on the health measure chosen. However, a few countries performed above average on all three health measures (Iceland, Sweden, Spain, Czech Republic and France). In other words, these countries attained a higher level of population health than expected, given their level of health spending, education and GDP. At the same time, some countries performed consistently worse than average, such as Denmark, Hungary, Slovakia, Portugal, Luxembourg, Germany, and Austria. Note that a zero distance means this country has actual performance as predicted and hence is at the average level.

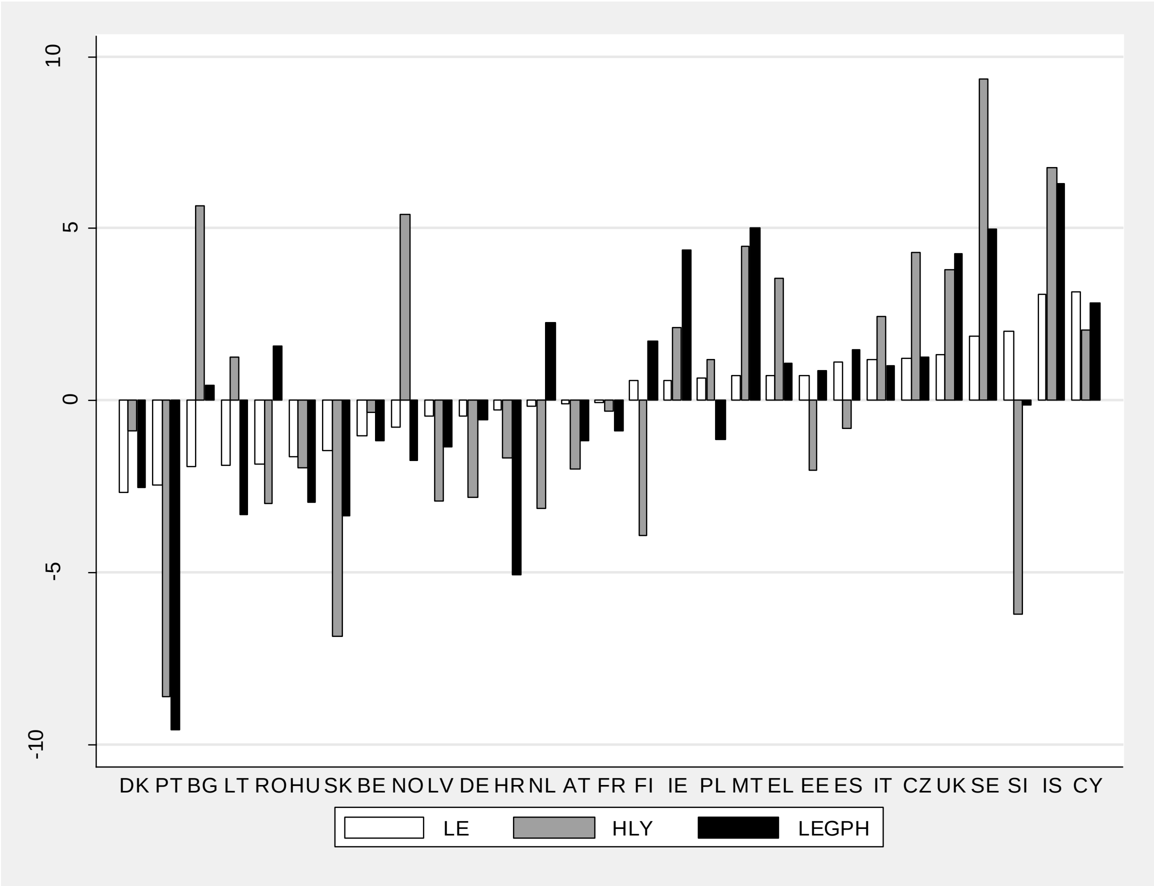

Figure 4.4: Health system efficiency estimated by parametric analyses (actual – predicted population health in years)

Figure 4.5 presents the relative efficiency of health systems in achieving population health as estimated by a non-parametric method, the Data Envelopment Analysis (DEA). Similar to the parametric model above, the DEA was based on cross-sectional 2010 data including GDP and education as additional inputs. The higher the score, the more efficient a country is. A country with a score of 1 is regarded efficient. The majority of countries that are relatively efficient according to the parametric approach (e.g. Iceland and Sweden) also score high on technical efficiency obtained by a DEA. Again, Denmark, Lithuania and Slovakia are among the worst performing countries, as are Slovenia, Germany, and Austria for HLY and LEGPH. However, some obvious differences also arise. Probably, most notable is the result that Portugal and Romania do very well according to a DEA, but not according to the parametric approach. For Romania, this could be explained by very few countries having comparable low levels of spending per capita, and hence being an outlier that will be placed artificially on the frontier by DEA. For Portugal however that explanation cannot be used, its level of spending is quite modal.

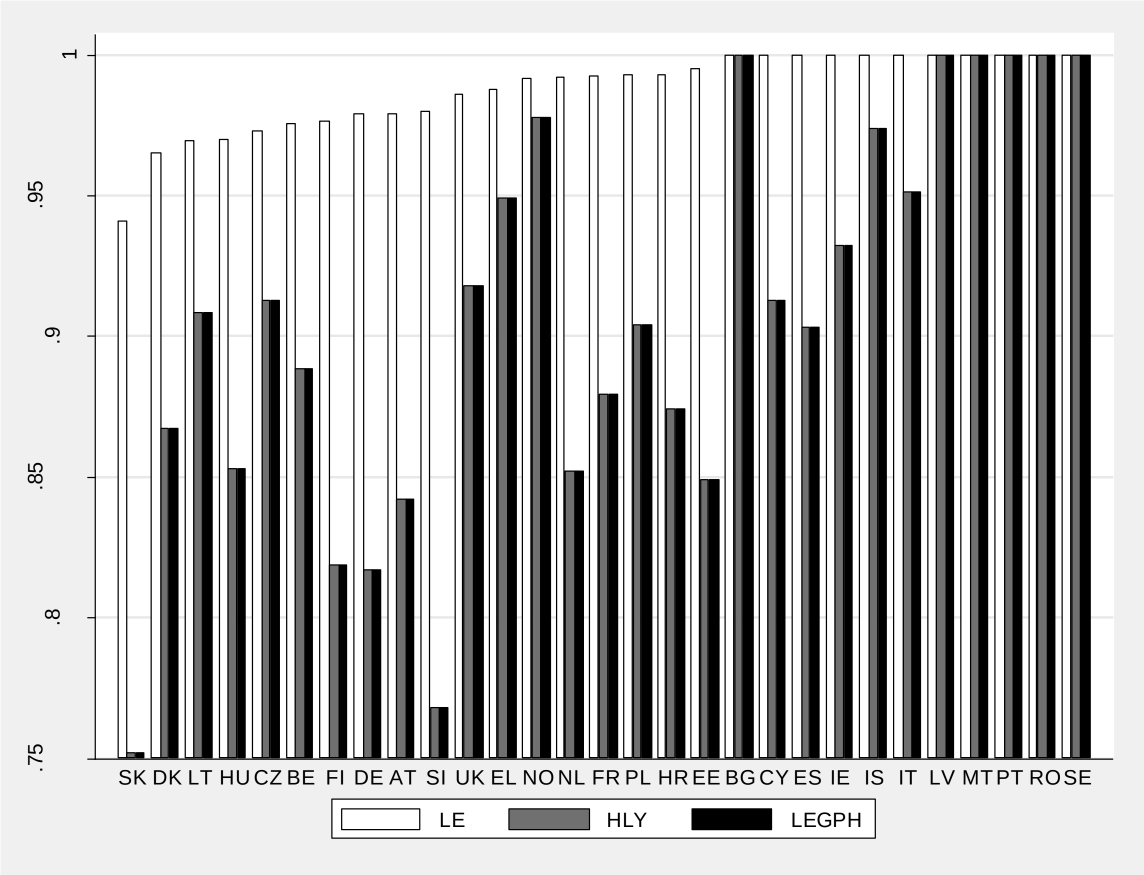

Figure 4.5: Health system efficiency estimated by DEA (efficiency score between 0 and 1)

4.2 Health system cost-effectiveness adjusted for lifestyle - Results scenario 1

Changes in health outcomes and health spending

Table 4.2 presents results after standardization for differences in life style, for the outcome measures life expectancy (LE), healthy life expectancy (LEGPH, HLY) and total curative health expenditures (TCHE) in scenario 1("best of all") as compared to the reference scenario. In this scenario, we applied the prevalence of the best-performing country (with respect to the specific lifestyle behaviour at that specific age and gender category) to all other countries. Thus, we took the most healthy behaviour actually observed for a certain age and gender and assumed all countries would have this behaviour at this age and gender. The scenarios specified smoking, alcohol and BMI. Risk factors were assumed to be independent, in line with the corrected ORs. The results of the other scenarios are presented in section 4.3. The baseline (absolute) values can be found in Appendix 9.2.

The table illustrates that lifestyle has quite a big impact on (healthy) life expectancy and that the increases in healthy life expectancy are bigger than on life expectancy. Life expectancy increases between 0.36 years (Italy) and 2.3 years (Latvia), while HLY increased between 0.92 years (Sweden) and 4.9 years (Croatia). The impact of lifestyle on per capita health expenditures is rather modest as the additional costs of living longer are more or less outweighed by the cost-savings induced by more favorable lifestyle patterns and lower disability prevalence in the different countries.

On balance, health care expenditures per capita increase a bit (up to 95 euros per capita in Norway).

Table 4.2: Changes in health and health expenditures in scenario 1 compared to the base case scenario

	Difference between scenario 1 and base case scenario			
Country	LE (years)	LEGPH (years)	HLY (years)	TCHE* (€)
Austria	0.95	2.98	2.18	38
Belgium	1.11	3.21	2.21	31
Bulgaria	1.31	2.77	2.19	10
Croatia	1.65	3.77	4.91	30
Cyprus	1.21	3.90	2.90	23
Czech Republic	1.21	3.90	2.90	21
Denmark	1.41	2.67	2.00	60
Estonia	1.66	3.79	2.99	19
Finland	0.85	3.16	2.86	15
France	1.05	2.73	1.69	39
Germany	1.15	3.46	2.34	35
Greece	1.80	3.73	2.71	33
Hungary	1.67	4.14	3.26	19
Iceland	2.06	3.95	3.25	47
Ireland	0.63	2.93	2.15	21
Italy	0.36	2.59	1.58	14
Latvia	2.25	4.87	3.99	13
Lithuania	1.89	3.58	3.23	21
Luxembourg	TBA	TBA	TBA	TBA
Malta	1.26	4.95	3.00	13
Netherlands	1.38	2.68	2.14	52
Norway	2.14	3.66	3.07	95
Poland	1.86	3.74	3.36	22
Portugal	0.65	3.75	2.73	12
Romania	1.38	2.75	2.46	11
Slovakia	1.30	2.79	2.30	20
Slovenia	1.20	3.42	2.79	24
Spain	1.21	4.38	3.25	29
Sweden	0.66	1.25	0.92	26
United Kingdom	0.99	3.22	2.42	21

*Total curative care spending (€ per capita, price level 2010)

Figure 4.6 illustrates that – on average - the hypothetical lifestyle improvements according to scenario 1 had a larger impact on life expectancy in unhealthier countries compared to healthier countries (in terms of life expectancy). This is related to the unhealthier lifestyle behaviour in countries with low life expectancy at baseline (there is more to be gained).

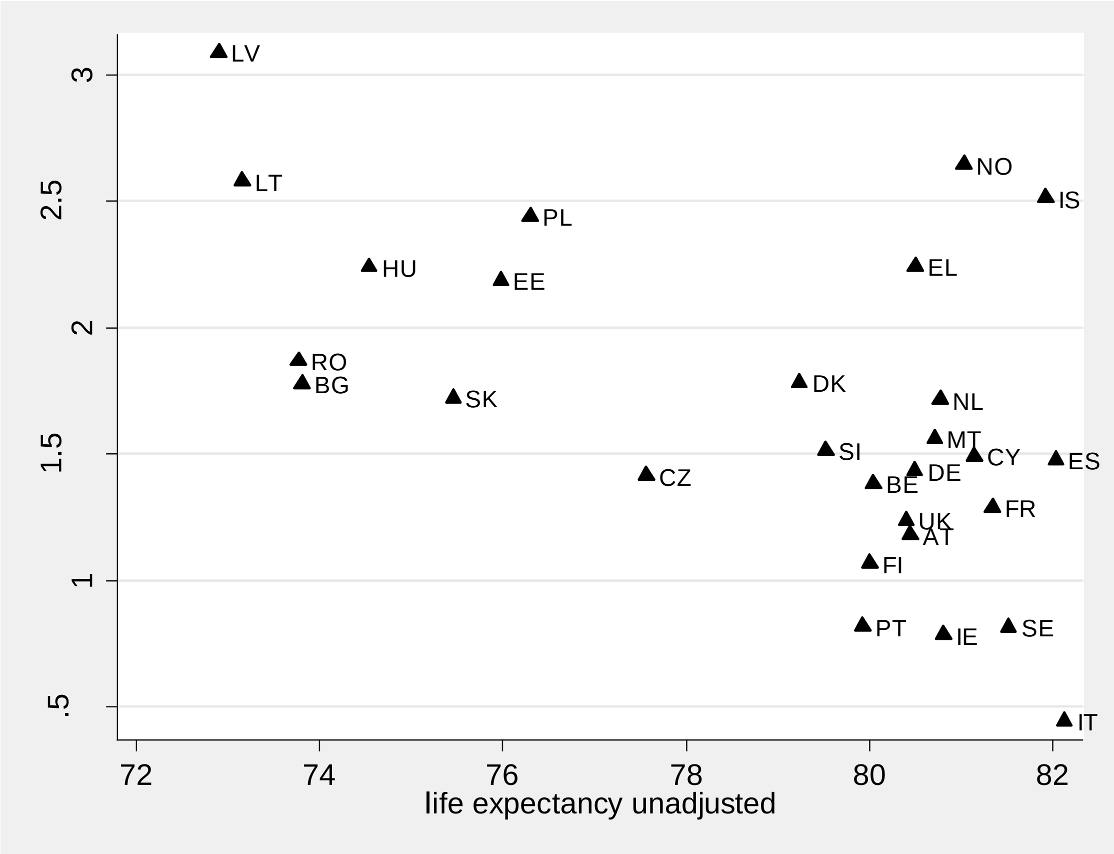

Figure 4.6: Relative change in life expectancy across all levels of life expectancy per country in scenario 1

Changes in health system efficiency

After adjustment for lifestyle, the relation between spending and health was weaker and the elasticities were reduced to some extent. For instance, the elasticity of curative care spending with respect to life expectancy decreased from 0.057 to 0.053. Figure 4.7 to Figure 4.9 show the relationship between health spending and population health before (unadjusted) and after (adjusted) standardization for lifestyle in scenario 1 ("best of all"). This scenario was defined by a hypothetical shift for each age and gender category to the best observed lifestyle among all countries and thus presents a potential, but hypothetical, most healthy ideal situation. As mentioned above, the impact of standardization on population health differences was much larger compared to its impact on differences in health spending between countries. As a result, the relationship between health spending and population health remained similar and was just shifted upward a bit.

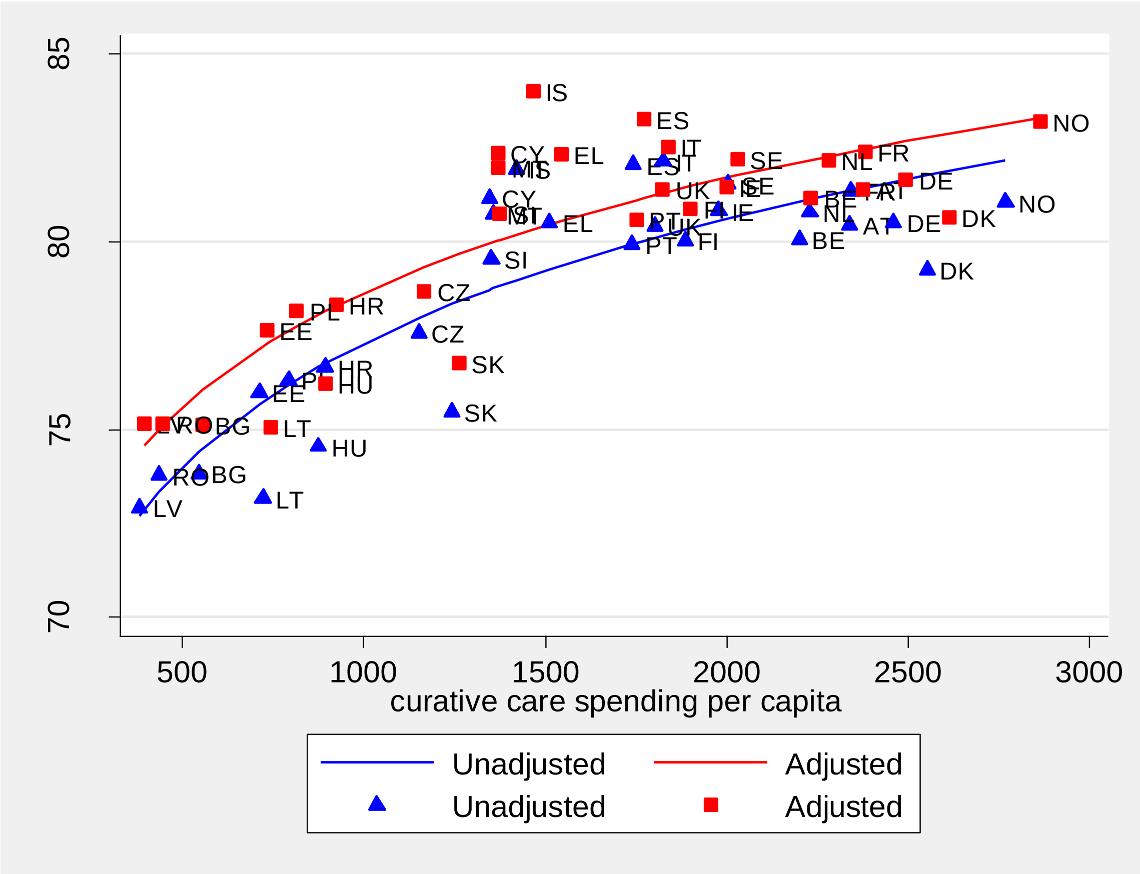

Figure 4.7: The association between curative care spending and life expectancy, unadjusted and adjusted for lifestyle behaviour (scenario 1)

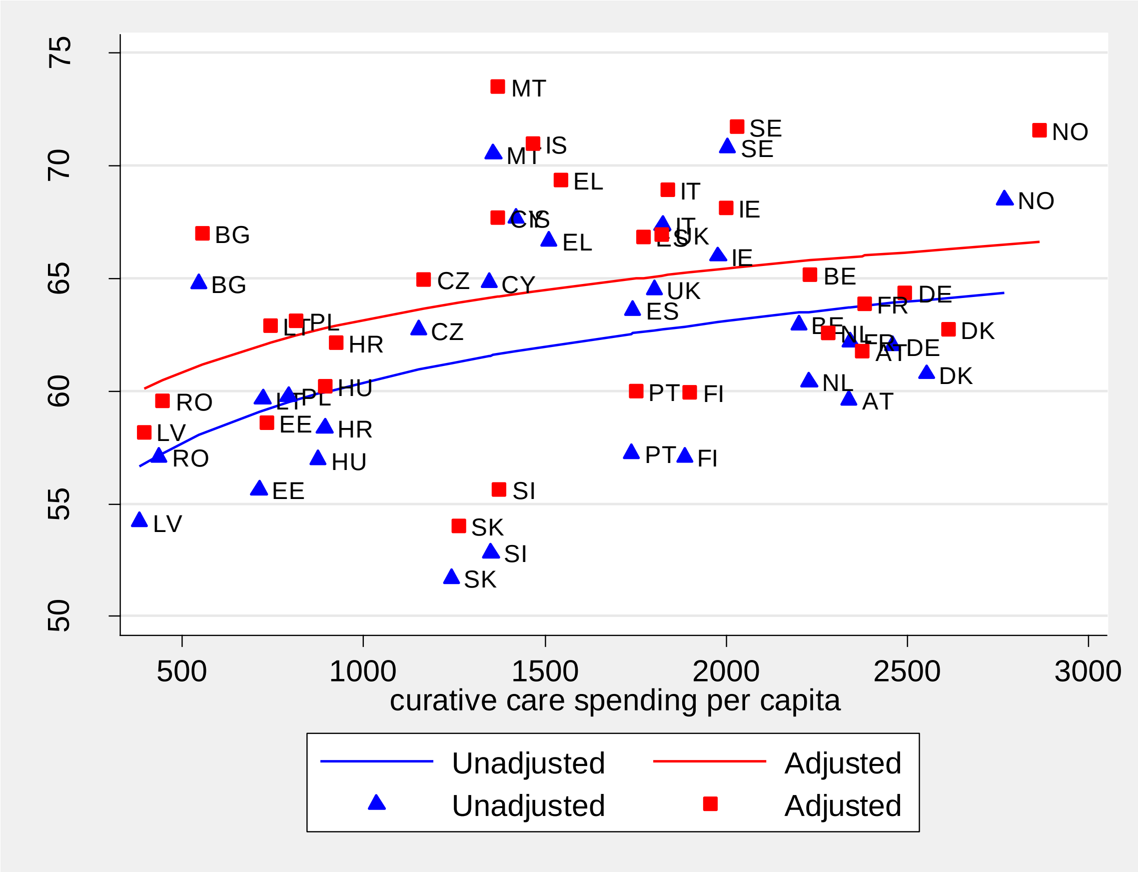

Figure 4.8: The association between curative care spending and healthy life years, unadjusted and adjusted for lifestyle behaviour (scenario 1)

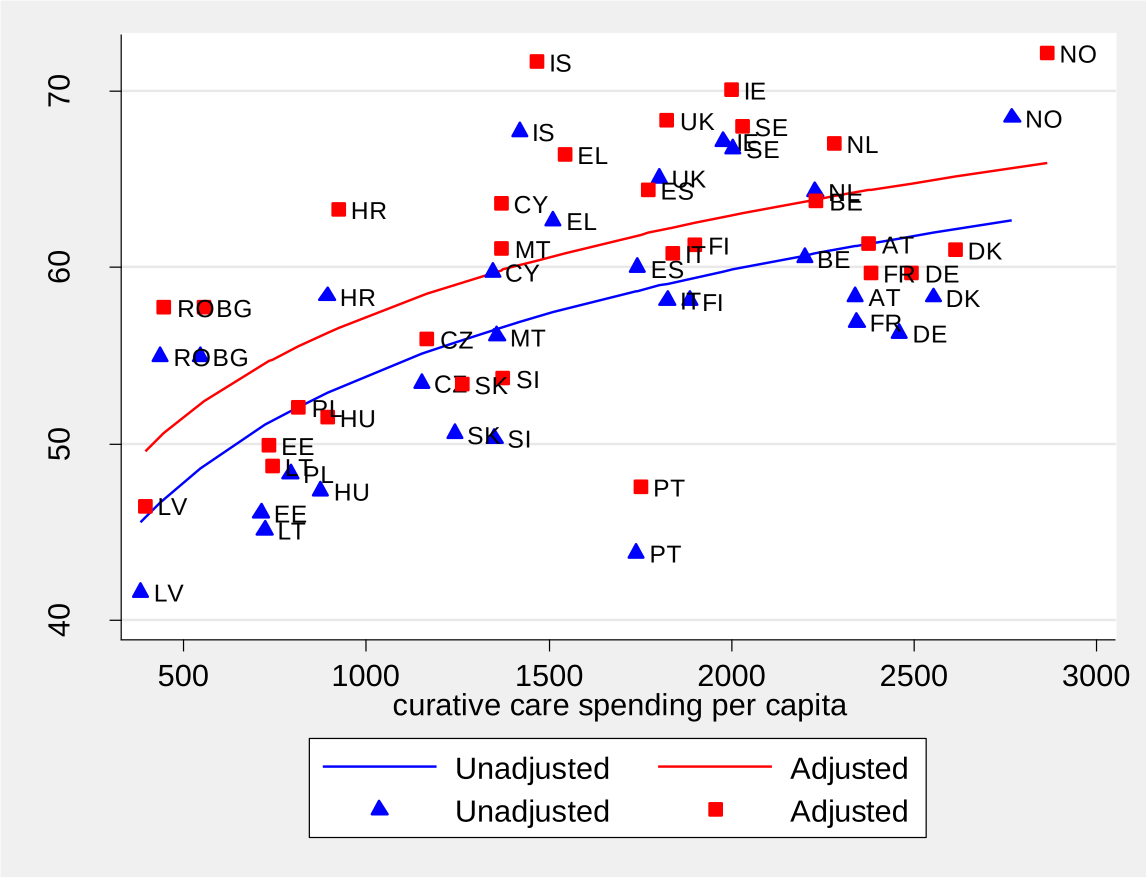

Figure 4.9: The association between curative care spending and life expectancy in good perceived health, unadjusted and adjusted for lifestyle behaviour (scenario 1)

The technical efficiency, as presented in section 4.1, was affected to some extent through standardization as population health changed differently across the countries (see Figure 4.7 to *Figure 4.9*). Nevertheless, the general pattern remained similar. In order to illustrate the impact of standardisation on country-specific efficiency scores (using life expectancy as outcome measure), Figure 4.10 shows the correlation between the unadjusted and adjusted efficiency scores (based on the parametric method). It demonstrates a high correlation between the unadjusted and adjusted efficiency measure (r=0.84).

Concluding, we can say that while current lifestyle is important for health it is less important for health spending, in particular regarding the variation in health spending between countries. Consequently, also the influence on cross-country differences in health system cost-effectiveness was limited. Please note that these adjusted cost-effectiveness estimates should not be interpreted as policy scenarios. They reflect hypothetical immediate changes in lifestyle and ignore intervention costs. They are an indication as to how lifestyle confounds the observed relation between health care spending and health outcomes.

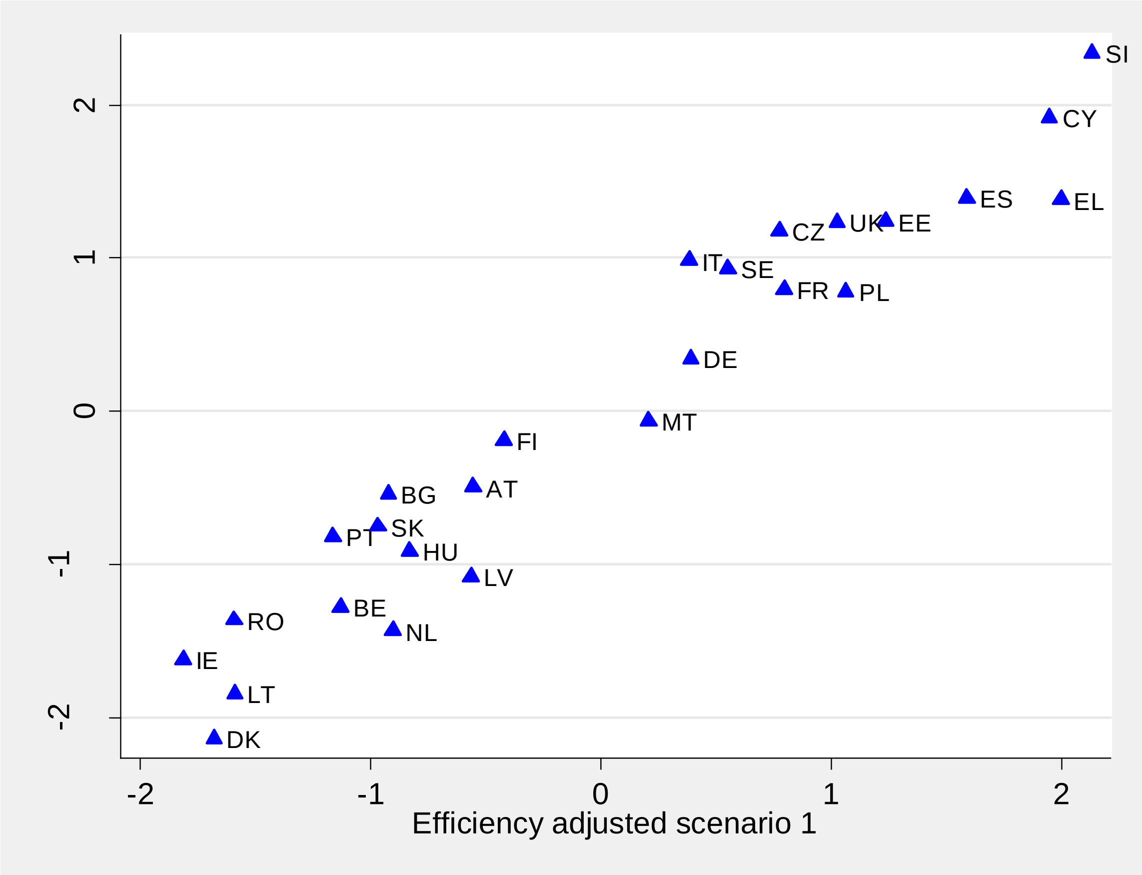

Figure 4.10: The association between country-specific efficiency scores, using life expectancy as outcome, unadjusted and adjusted for lifestyle behaviour (scenario 1)

4.3 Health system cost-effectiveness adjusted for lifestyle - Results scenarios 2 to 6

The figures and tables in this paragraph show the results of the other standardization scenarios 2 to 6 (see 2.5), i.e.:

- 2a: 100% in healthiest category for all lifestyle variables
- 2b: 100% in healthiest category for smoking
- 2c: 100% in healthiest category for BMI
- 2d: 100% in healthiest category for alcohol consumption
- 3a: 100% in most unhealthy category for all lifestyle variables
- 3b: 100% in most unhealthy category for smoking
- 3c: 100% in most unhealthy category for BMI
- 3d: 100% in most unhealthy category for alcohol consumption
- 4: equal division across lifestyle categories
- 5: lifestyle prevalence of country with median population health
- 6: lifestyle prevalence of country with median health spending

Changes in health outcomes and health spending

Table 4.3 to Table 4.6 show that the hypothetical changes in lifestyle behaviour in the scenarios clearly affect the three population health measures. Obviously, scenario 2a (all populations in healthiest category for all lifestyle variables) generates the largest gain in life expectancy, i.e. between 2.4 years in Italy (+3%) and 5.1 years in Latvia (+7%).

As shown in Table 4.4 and Table 4.5, the changes in healthy life expectancy were even larger than the gains in life expectancy for scenario 2a. Gains in terms of Healthy Life Years varied between 4.8 years (+7%) in Sweden and 8.1 years (+19%) in Latvia; and in terms of Life Expectancy in Good Perceived Health between 6.6 years (+9.8%) in Sweden and 9.9 years (+18%) in Latvia.

The results differed between the lifestyle variables. Changing current smoking prevalence (scenario 2b and 3b) showed a greater impact in terms of (healthy) life expectancy, compared to BMI (scenario 2c and 3c). Changes in current alcohol consumption (scenario 2d and 3d) produced a rather small change in (healthy) life expectancy. This reflects the values of odds ratios and relative risks for the different lifestyle factors.

In all scenarios, and for all health measures, differences between countries were reduced a bit, because the countries with lower (healthy) life expectancy had more unhealthy lifestyle behaviours as well. Nevertheless, differences remained substantial and countries with high (healthy) life expectancy at baseline remained high after standardization. This finding holds for all scenarios. In other words, standardizing for differences in lifestyle cannot explain all cross-country variation in population health.

Finally, similar to the results for scenario 1, changes in health spending at country level were small in all scenarios (Table 4. 6). We also re-estimated the regression models using adjusted curative care spending and adjusted population health. Table 4.7 shows the elasticity of health outcomes with respect to changes in health spending. The table shows that elasticity is rather stable across the standardization scenarios, except for scenario 3a (100% in most unhealthy category for all lifestyles).

Table 4.3: Changes in Life Expectancy (years) by country and scenario

Scenario no[2]	2a	2b	2c	2d	3a	3b	3c	3d	4	5	6
Austria	3.09	1.79	1.24	0.07	-6.27	-3.75	-3.13	-0.04	-2.48	0.14	0.35
Belgium	3.30	1.95	1.27	0.09	-6.29	-3.78	-3.15	0.01	-2.42	0.26	0.49
Bulgaria	3.74	2.16	1.57	0.02	-6.07	-3.67	-3.19	0.01	-2.24	0.33	0.65
Croatia	4.03	2.11	1.79	0.06	-5.64	-3.70	-2.60	0.07	-1.86	0.75	1.00
Cyprus	3.18	1.80	1.32	0.03	-5.44	-3.38	-2.58	-0.01	-1.98	0.51	0.67
Czech Republic	3.42	1.77	1.59	0.04	-6.26	-3.96	-2.97	-0.02	-2.41	0.20	0.46
Denmark	3.65	2.37	1.20	0.12	-6.08	-3.51	-3.34	0.02	-2.15	0.54	0.79
Estonia	4.31	2.43	1.77	0.03	-6.35	-3.82	-3.42	0.03	-2.32	0.61	0.90
Finland	3.07	1.62	1.41	0.04	-6.52	-4.10	-3.12	0.00	-2.69	0.00	0.22
France	3.34	1.94	1.32	0.09	-6.66	-3.99	-3.37	0.00	-2.60	0.18	0.39
Germany	3.83	2.33	1.32	0.07	-6.51	-3.95	-3.33	-0.06	-2.59	0.28	0.49
Greece	3.95	2.26	1.63	0.05	-5.34	-3.29	-2.69	0.03	-1.64	1.03	1.20
Hungary	4.43	2.37	1.97	0.00	-6.36	-4.07	-2.99	0.03	-2.16	0.59	0.92
Iceland	3.98	2.02	1.77	0.15	-4.82	-3.21	-2.26	0.18	-1.23	1.34	1.51
Ireland	2.73	1.44	1.19	0.09	-6.55	-4.14	-3.03	0.01	-2.84	-0.19	0.03
Italy	2.42	1.33	0.99	0.10	-6.65	-4.07	-3.02	-0.08	-2.96	-0.39	-0.21
Latvia	5.05	2.97	1.98	-0.01	-6.04	-3.55	-3.30	0.06	-1.84	1.09	1.46
Lithuania	4.70	2.51	2.11	0.00	-6.50	-4.04	-3.45	0.12	-2.30	0.69	1.06
Malta	3.29	1.38	1.79	0.02	-5.62	-3.95	-2.16	0.05	-2.04	0.52	0.70
Netherlands	3.47	2.12	1.21	0.15	-5.79	-3.43	-3.00	0.04	-2.01	0.59	0.81
Norway	4.23	2.25	1.75	0.17	-5.14	-3.31	-2.55	0.19	-1.35	1.36	1.55
Poland	4.46	2.71	1.67	0.03	-6.12	-3.59	-3.23	0.00	-1.99	0.84	1.13
Portugal	2.89	1.40	1.38	0.07	-6.78	-4.32	-2.99	0.00	-2.89	-0.22	0.00
Romania	4.19	2.27	1.71	0.10	-6.60	-4.09	-3.36	0.07	-2.53	0.29	0.63
Slovakia	3.83	2.09	1.64	0.03	-6.29	-3.91	-3.03	-0.02	-2.34	0.32	0.61
Slovenia	3.47	1.62	1.77	0.05	-6.13	-4.06	-2.67	0.02	-2.27	0.36	0.58
Spain	3.34	1.78	1.45	0.07	-5.97	-3.79	-2.65	0.00	-2.17	0.45	0.62
Sweden	2.71	1.63	1.02	0.05	-6.43	-3.83	-3.14	-0.07	-2.71	-0.12	0.09
UK	3.16	1.79	1.26	0.13	-6.38	-3.96	-3.09	0.04	-2.53	0.15	0.38

[2] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption; 4: equal division; 5: country with median population health; 6: country with median health spending

Table 4.4: Changes in Healthy Life Years (years) by country and scenario[3]

	2a	2b	2c	2d	3a	3b	3c	3d	4	5	6
Austria	6.57	2.30	2.49	1.78	-14.78	-2.79	-7.53	-3.63	-3.96	-0.34	-0.72
Belgium	6.48	2.20	2.66	1.74	-14.84	-3.18	-7.37	-3.39	-4.05	-0.28	-0.62
Bulgaria	5.60	2.13	2.36	1.15	-9.82	-2.73	-5.23	-1.78	-2.44	0.38	0.33
Croatia	7.84	2.36	3.43	2.12	-10.61	-2.49	-5.58	-2.43	-1.40	1.59	1.35
Cyprus	6.55	2.01	2.82	1.80	-11.42	-2.44	-5.63	-2.67	-2.15	0.84	0.55
Czech Republic	6.23	1.95	2.83	1.40	-12.96	-3.05	-6.15	-2.90	-3.33	-0.02	-0.26
Denmark	7.02	3.20	2.81	1.18	-19.27	-4.02	-8.90	-4.89	-5.93	-1.04	-1.47
Estonia	7.20	2.39	2.82	1.84	-12.66	-2.41	-6.37	-2.93	-2.80	0.60	0.32
Finland	7.62	2.23	3.33	2.12	-16.37	-3.55	-7.85	-3.98	-4.25	0.00	-0.46
France	5.95	2.16	2.42	1.47	-15.35	-2.97	-7.70	-3.85	-4.53	-0.84	-1.21
Germany	6.68	2.31	2.57	1.82	-14.43	-2.94	-7.28	-3.34	-3.78	-0.12	-0.47
Greece	5.81	1.81	2.53	1.39	-8.19	-1.77	-4.39	-1.97	-1.24	1.04	0.84
Hungary	7.21	2.09	3.03	2.02	-10.69	-2.56	-5.66	-2.16	-1.85	1.08	0.88
Iceland	7.31	2.49	3.94	0.97	-14.99	-3.32	-6.12	-3.94	-3.57	0.76	0.39
Ireland	6.26	1.78	2.46	2.09	-14.05	-3.59	-6.83	-2.61	-3.85	-0.14	-0.42
Italy	5.22	1.37	1.76	2.13	-12.34	-2.99	-6.71	-2.08	-3.45	-0.47	-0.74
Latvia	8.06	2.73	3.21	1.96	-11.27	-2.06	-5.92	-2.43	-1.77	1.61	1.38
Lithuania	7.00	2.21	3.01	1.62	-9.88	-2.45	-5.30	-1.82	-1.86	1.14	1.01
Malta	6.20	1.44	3.16	1.55	-8.78	-2.96	-4.10	-1.55	-1.45	1.30	1.13
Netherlands	6.70	2.50	2.77	1.48	-16.39	-3.07	-7.82	-4.34	-4.60	-0.57	-1.00
Norway	7.28	2.91	3.70	0.75	-15.62	-3.53	-6.34	-4.00	-3.98	0.58	0.28
Poland	7.45	2.48	2.75	2.07	-11.62	-2.47	-6.23	-2.23	-2.21	1.07	0.83
Portugal	6.81	1.71	2.68	2.44	-13.12	-2.90	-7.07	-2.61	-2.99	0.36	0.00
Romania	6.35	1.95	2.43	1.82	-10.51	-2.46	-5.81	-2.10	-2.38	0.42	0.23
Slovakia	5.99	1.88	2.40	1.68	-11.92	-2.19	-5.75	-2.90	-2.76	0.19	-0.10
Slovenia	7.65	2.20	3.42	1.96	-16.07	-3.36	-7.53	-4.24	-4.17	-0.08	-0.57
Spain	7.33	2.08	2.91	2.29	-12.72	-2.65	-6.56	-2.62	-2.55	0.91	0.55
Sweden	4.83	1.82	2.08	1.01	-15.88	-4.06	-7.27	-3.13	-5.41	-1.38	-1.64
UK	6.68	2.16	2.74	1.96	-14.72	-3.48	-7.22	-3.22	-3.94	-0.04	-0.35

[3] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption; 4: equal division; 5: country with median population health; 6: country with median health spending

Table 4.5 Changes in Life Expectancy in Good Perceived Health (years) by country and scenario[4]

	2a	2b	2c	2d	3a	3b	3c	3d	4	5	6
Austria	8.40	3.04	2.90	2.52	-19.31	-4.54	-11.16	-3.59	-4.65	-0.43	-0.89
Belgium	8.69	3.04	3.44	2.40	-19.94	-5.22	-10.64	-1.89	-4.66	-0.25	-0.69
Bulgaria	6.51	2.37	2.51	1.70	-11.96	-2.82	-6.86	7.66	-2.11	0.56	0.38
Croatia	9.80	3.11	4.14	2.73	-14.14	-4.22	-7.59	-2.95	-1.50	2.03	1.75
Cyprus	8.29	2.56	3.42	2.38	-14.12	-3.68	-7.37	2.00	-1.84	1.23	0.91
Czech Republic	7.17	2.36	2.79	1.89	-15.91	-3.86	-8.92	5.41	-3.89	-0.35	-0.71
Denmark	9.03	3.90	3.63	1.73	-24.53	-6.19	-13.52	-3.99	-7.25	-1.46	-2.09
Estonia	9.14	3.11	3.07	2.55	-16.92	-4.17	-10.34	5.65	-4.20	0.44	-0.09
Finland	8.19	2.50	3.49	2.29	-17.77	-4.76	-9.44	-6.19	-3.96	0.00	-0.41
France	8.39	3.09	3.17	2.28	-20.86	-5.03	-11.88	0.30	-5.53	-0.93	-1.46
Germany	9.31	3.21	3.38	2.68	-19.81	-5.12	-11.23	1.42	-4.75	-0.16	-0.68
Greece	7.53	2.51	3.20	1.91	-11.49	-2.78	-6.05	1.67	-1.03	1.42	1.18
Hungary	8.56	2.64	2.97	2.74	-13.05	-3.48	-7.77	6.94	-2.10	1.42	1.09
Iceland	8.79	3.12	4.81	1.21	-20.34	-5.30	-9.09	-5.07	-4.23	0.63	0.16
Ireland	7.77	2.39	3.08	2.66	-19.12	-5.67	-9.73	-4.45	-4.40	-0.12	-0.43
Italy	7.41	2.05	2.20	3.20	-17.49	-4.60	-9.79	6.58	-4.06	-0.44	-0.84
Latvia	9.94	3.59	3.12	2.69	-14.54	-3.31	-9.41	9.35	-2.86	1.66	1.14
Lithuania	7.82	2.68	2.82	2.04	-13.30	-3.11	-8.15	12.10	-2.82	0.90	0.55
Malta	9.83	2.39	4.46	2.92	-15.62	-4.53	9.41	12.58	-1.86	1.88	1.46
Netherlands	7.98	3.08	3.31	1.80	-21.23	-5.22	-15.83	-9.66	-5.32	-0.77	-1.22
Norway	8.70	3.44	4.55	0.98	-21.20	-5.54	-9.59	-5.14	-4.84	0.33	-0.05
Poland	8.36	2.88	2.57	2.56	-14.48	-3.39	2.52	8.57	-2.90	0.89	0.50
Portugal	8.81	2.59	2.57	3.53	-16.27	-4.65	3.54	10.04	-3.94	0.56	0.00
Romania	6.79	2.18	2.48	2.03	-11.65	-3.22	-6.64	-0.62	-2.21	0.46	0.29
Slovakia	7.22	2.30	2.67	2.07	-14.57	-3.76	-8.19	-2.73	-3.36	0.10	-0.22
Slovenia	9.20	2.83	3.73	2.46	-19.03	-5.07	-9.74	-3.26	-4.93	-0.20	-0.78
Spain	9.47	2.79	3.54	3.15	-16.67	-4.28	-5.69	0.35	-2.55	1.16	0.74
Sweden	6.56	2.13	2.84	1.70	-23.57	-6.42	-6.14	-0.01	-7.19	-2.29	-2.77
UK	8.22	2.80	3.47	2.35	-19.22	-5.45	-10.47	-4.63	-4.25	0.03	-0.32

[4] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption; 4: equal division; 5: country with median population health; 6: country with median health spending

Table 4.6: Changes in curative care spending per capita (€) by country and scenario[4]

Country	2a	2b	2c	2d	3a	3b	3c	3d	4	5	6
Austria	112	74	33	3	47	-6	24	-2	-54	15	19
Belgium	89	67	16	3	38	-19	30	0	-41	14	17
Bulgaria	28	26	1	0	28	-7	25	0	-8	4	6
Croatia	51	41	5	1	37	-12	34	1	-27	0	5
Cyprus	57	39	15	1	39	2	24	0	-20	13	14
Czech Republic	57	38	16	1	24	-10	17	0	-30	4	6
Denmark	156	107	40	5	38	12	-10	1	-58	29	35
Estonia	51	35	13	0	19	-5	11	0	-16	9	12
Finland	296	152	145	1	-226	-120	-124	0	-47	0	3
France	116	80	29	4	44	-19	31	0	-52	17	21
Germany	111	89	10	3	45	-32	42	-2	-47	15	18
Greece	74	55	15	1	44	2	25	1	-18	22	23
Hungary	54	49	1	0	41	-28	53	1	-13	9	13
Iceland	82	49	25	4	47	8	21	4	-13	24	28
Ireland	99	55	37	3	14	-10	-2	1	-75	-3	1
Italy	70	39	26	3	18	-2	5	-2	-56	-4	-2
Latvia	30	24	5	0	14	-3	10	1	-5	8	9
Lithuania	55	38	13	0	16	-14	13	2	-17	9	12
Malta	47	30	13	0	30	-12	28	1	-28	4	6
Netherlands	133	81	42	6	42	26	-10	2	-49	26	30
Norway	172	102	54	8	71	18	17	9	-32	49	59
Poland	50	39	8	0	27	-7	22	0	-7	14	16
Portugal	59	40	14	2	24	-31	34	0	-45	-3	0
Romania	34	22	8	1	15	-6	12	1	-11	4	6
Slovakia	55	53	-3	1	64	-35	78	-1	-9	13	16
Slovenia	72	48	19	1	39	-27	45	1	-32	10	12
Spain	80	52	21	2	40	-7	30	0	-33	15	16
Sweden	103	64	34	2	25	6	-4	-3	-70	2	5
UK	73	55	12	4	33	-17	26	1	-42	6	9

Table 4.7 Elasticity of population health to curative care spending in different scenarios (health spending coefficients from regression analyses)

	LE	HLY	LEGPH
Baseline	0.059	0.055	0.138
2a	0.047	0.045	0.129
2b	0.054	0.055	0.139
2c	0.053	0.051	0.139
2d	0.060	0.051	0.133
3a	0.066	-0.010	0.050
3b	0.064	0.048	0.122
3c	0.064	0.033	0.094
3d	0.059	0.036	0.030
4	0.060	0.027	0.109
5	0.056	0.038	0.118
6	0.055	0.036	0.117

Changes in health system efficiency

First, Figure 4.11 to Figure 4.13 present scatter plots following the adjustment scenarios 2b-2d. The figures present similar pictures as in Figure 4.1 (unadjusted) and Figure 4.7 to Figure 4.9 (adjusted using scenario 1). The figures show that the effect of a hypothetical change in lifestyle may differ between lifestyle factors. Scenario 2b, i.e. 100% of the population in the healthiest category for smoking, has the largest effect on population health (i.e. upward shift in the health production function). At the same time, changing all populations towards 100% in the healthiest

category for alcohol consumption generates a limited shift only (Figure 4.13). It shows that the impact of changing alcohol prevalences was limited in terms of both health spending and health outcomes. This partly reflects the relatively small odds ratios for alcohol, as they were estimated from the individual level data, which were self-reported. The total changes are affected by the combined result of morbidity and mortality risks for alcohol. While the self-reported data suit well to the prevalence numbers (also self-reported), they do have their drawback and some caution in the interpretation is warranted.
The figures also show that those countries under the curve in the unadjusted scenario (e.g. LT, HU, SK, BE, AT, DE, DK in Figure 4.11) all remain under the curve in the adjusted scenario. The same holds true for most countries above the curve. Which implies that standardization according to the scenarios has a small impact on countries' relative efficiency.

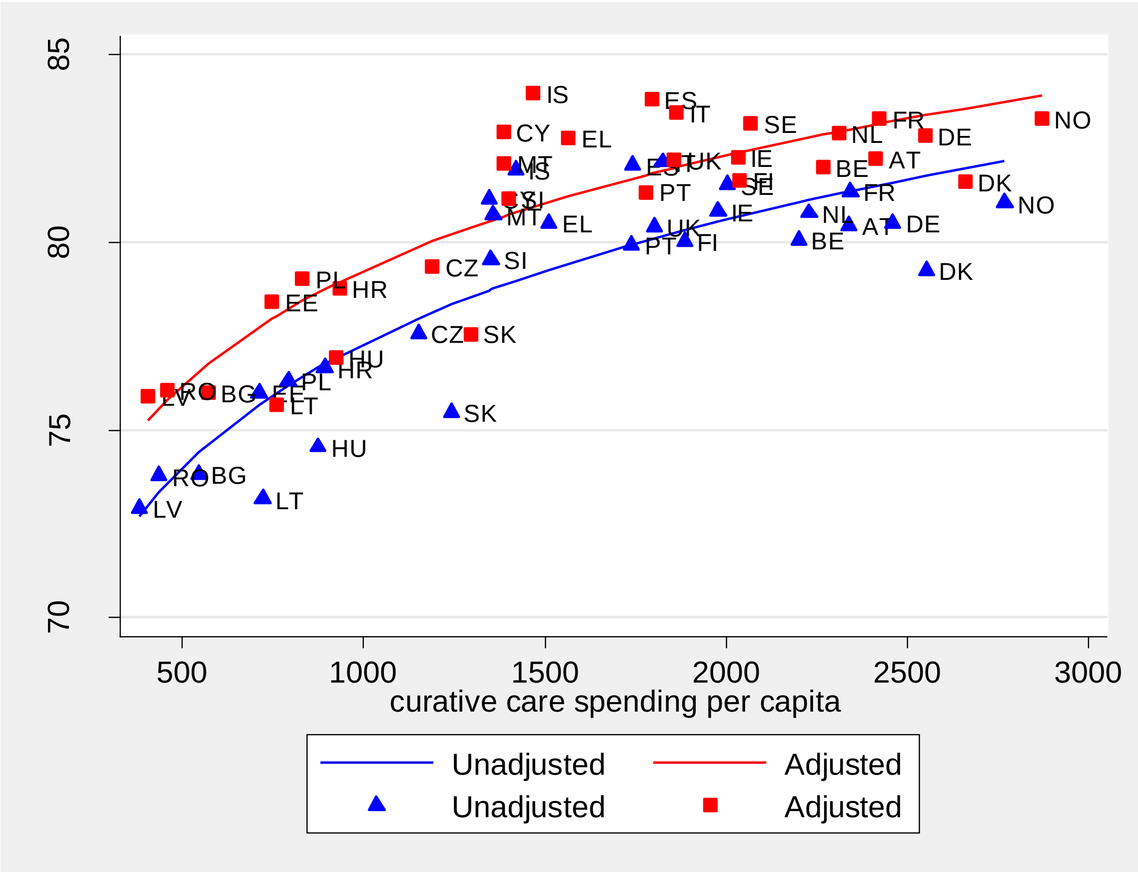

Figure 4.11 The association between curative care spending and life expectancy in good perceived health, unadjusted and adjusted for lifestyle behaviour (scenario 2b - 100% in healthiest category for smoking)

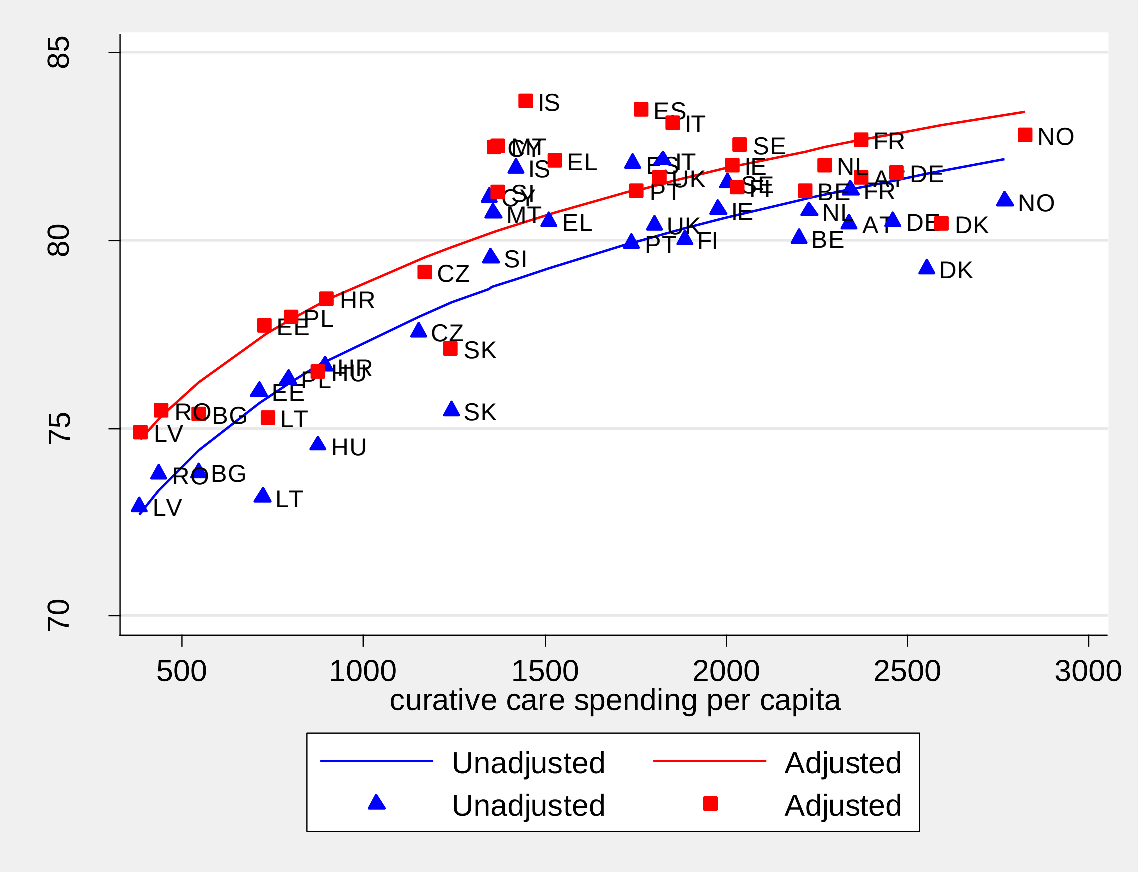

Figure 4.12 The association between curative care spending and life expectancy in good perceived health, unadjusted and adjusted for lifestyle behaviour (scenario 2c - 100% in healthiest category for BMI)

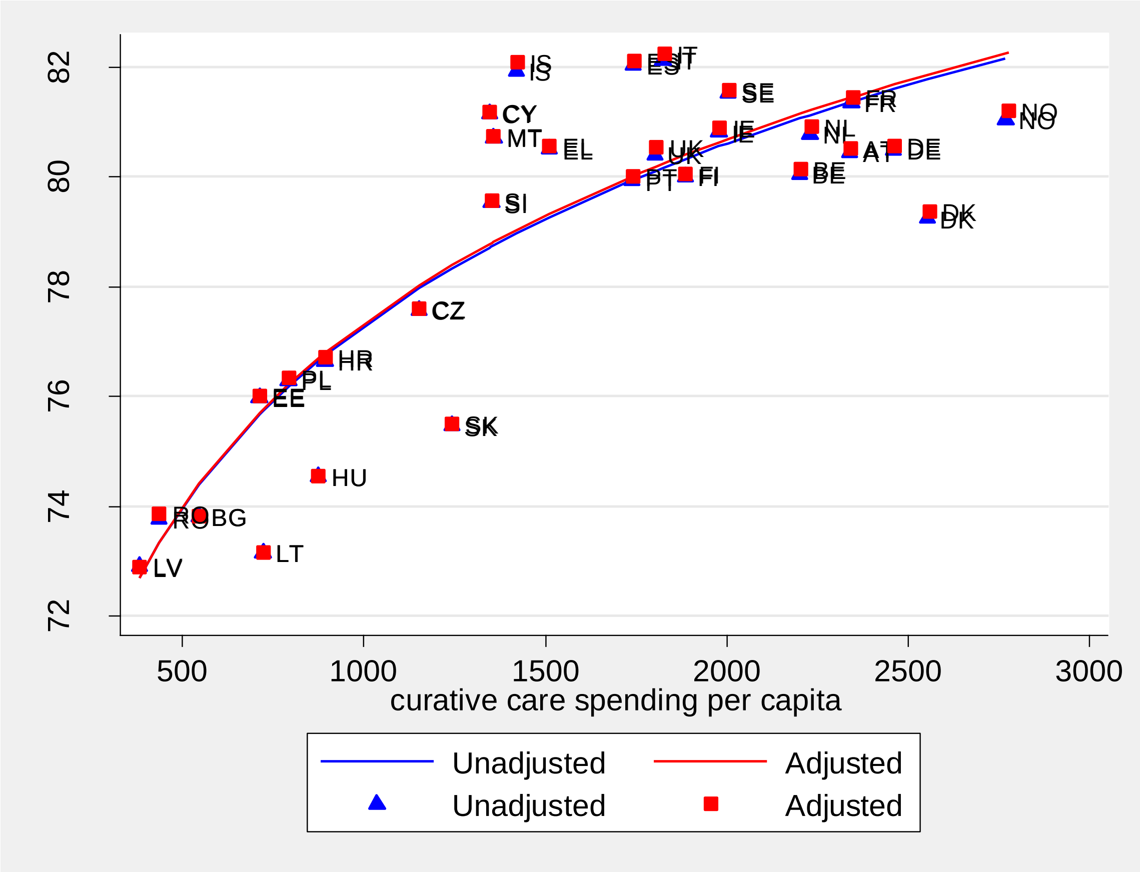

Figure 4.13 The association between curative care spending and life expectancy in good perceived health, unadjusted and adjusted for lifestyle behaviour (scenario 2d - 100% in healthiest category for alcohol).

4.4 Additional scenarios

Additional scenarios with disease modelling

In the additional scenarios, as described in section 2.9, we used dynamic models to investigate the impact of changes in lifestyle on disease prevalence, health outcomes and health spending over time. The analyses were performed using Dutch data. The analyses can only change one lifestyle factor at a time. Hence, the main analysis covers scenario 1 in three versions (each lifestyles shifts to its best observed value at all ages). They also include scenarios 2b-2d, in which the entire population moves for 100% to the most healthy lifestyle category at baseline, for smoking, BMI and alcohol use respectively. These two scenarios are then compared to the reference scenario. Below the mechanisms at stake are explained for the case of smoking for scenario 1b and scenario 2b. That is, at the start of the simulation period, the entire population shifts to a more healthy smoking behaviour, one that reflects best practice at each age throughout the set of countries considered (1b), or one that reflects the most healthy solution with only never smokers. Similar figures for BMI scenarios and alcohol scenarios are presented.

Reducing the prevalence of smoking has a clear impact on the prevalence of smoking-related diseases. Figure 4.14 illustrates this effect for lung cancer. The blue line refers to the reference scenario. The other two lines show a decline in the prevalence of lung cancer for scenario 1 and scenario 2, demonstrating a bigger effect for scenario 2.

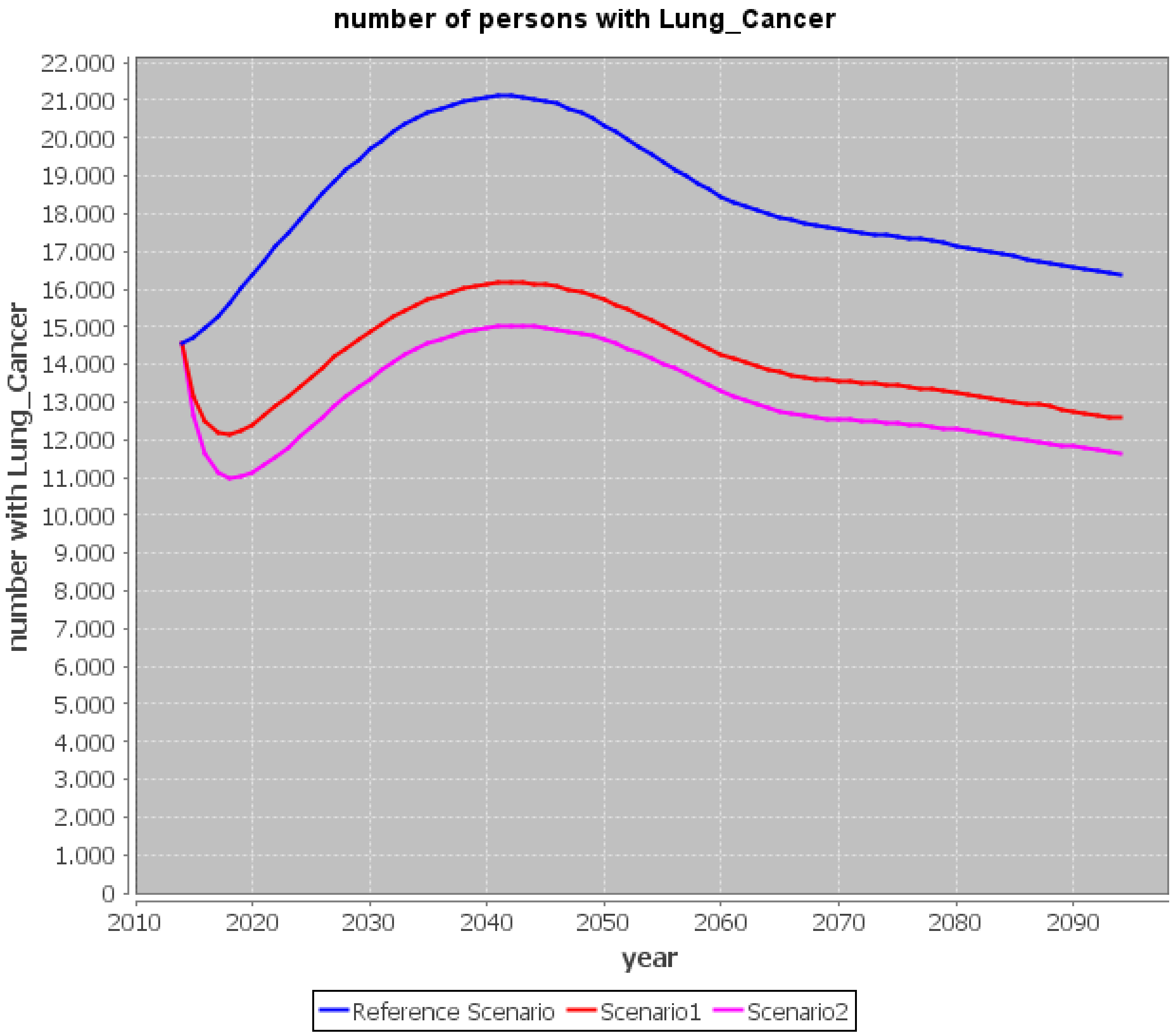

Figure 4.14: The number of persons with lung cancer in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for smoking"), and scenario 2 (100% in healthiest smoking category)

These prevalence figures differ between diseases as the impact of smoking varies from one disease to another. Figure 4.15 shows what happens with the prevalence of Chronic Obstructive Pulmonary Disease (COPD) over time where the decrease in smoking prevalence leads to an apparent decrease in the prevalence of COPD across all years. Similar results are obtained for other smoking related diseases such as ischaemic heart disease (IHD). (Figure 4.16).

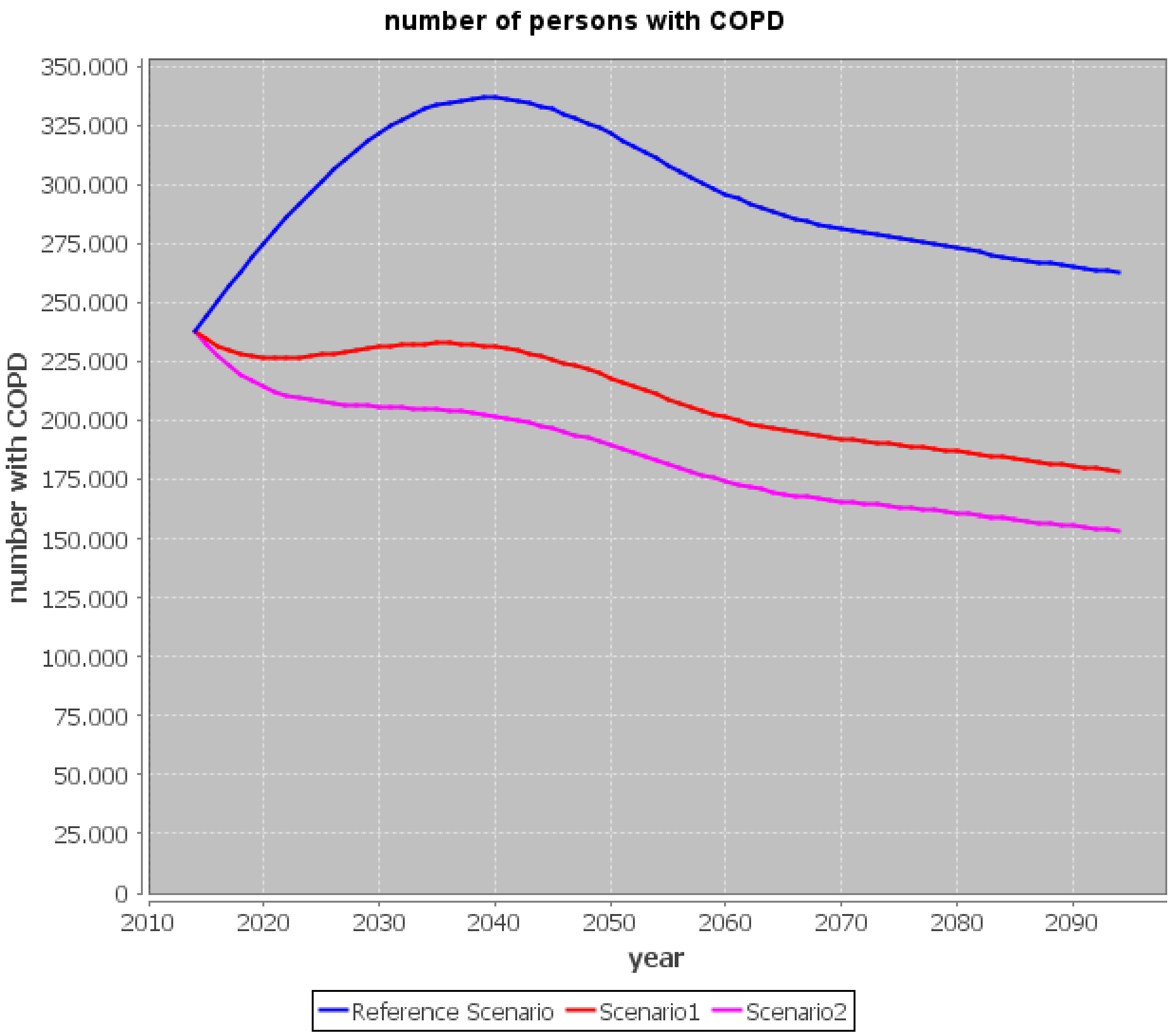

Figure 4.15 The number of persons with COPD in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for smoking"), and scenario 2 (100% in healthiest smoking category)

As mortality and morbidity from smoking-related diseases decline, the population lives longer. Figure 4.17 illustrates this, showing an increase in the size of the population over time in scenario 1 and 2. As a result the number of persons with chronic diseases not related to smoking will rise slightly.(Figure 4.18)

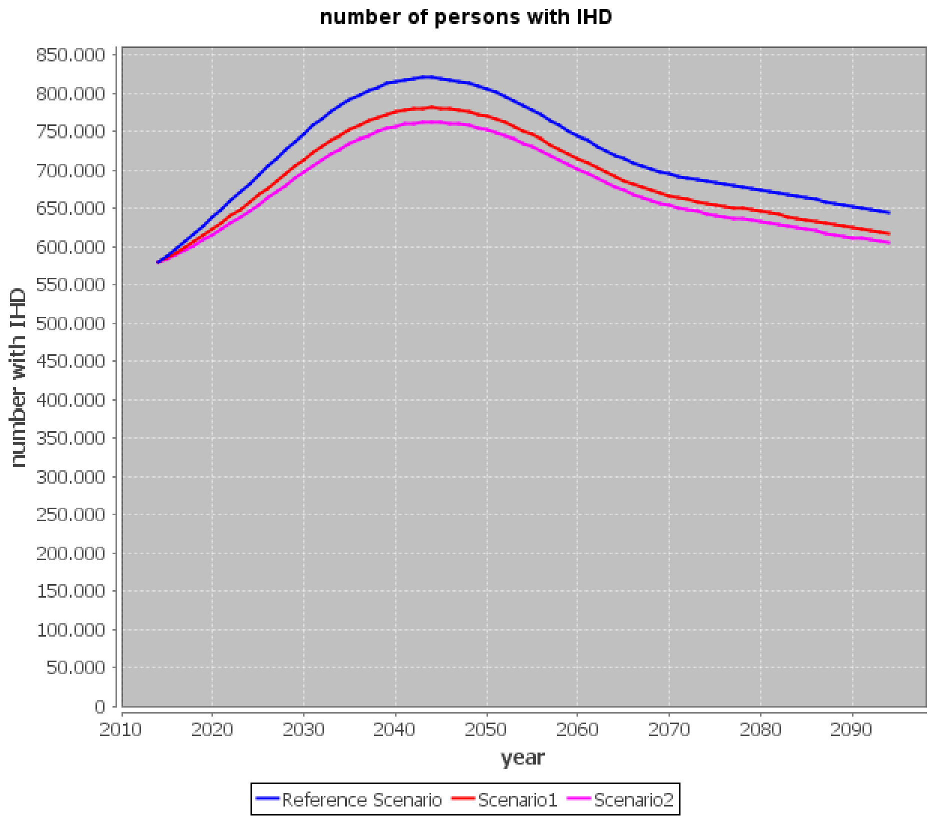

Figure 4.16: The number of persons with IHD in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for smoking"), and scenario 2 (100% in healthiest smoking category), for the Netherlands, base year 2010.

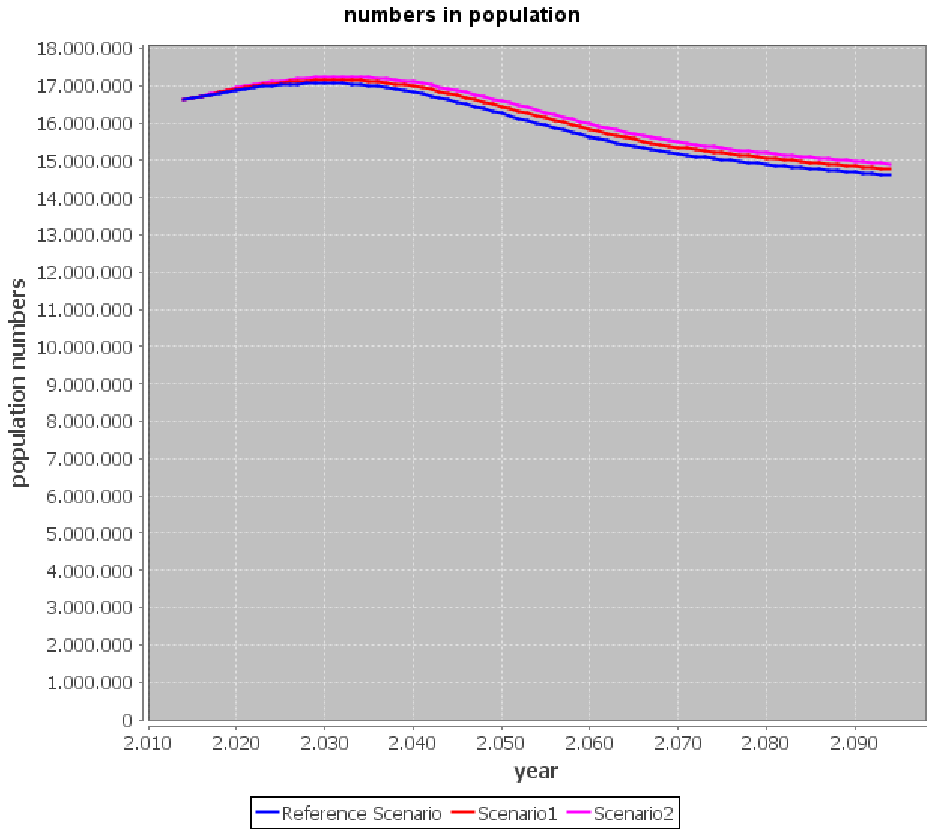

Figure 4.17 The total population in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for smoking"), and scenario 2 (100% in healthiest smoking category)

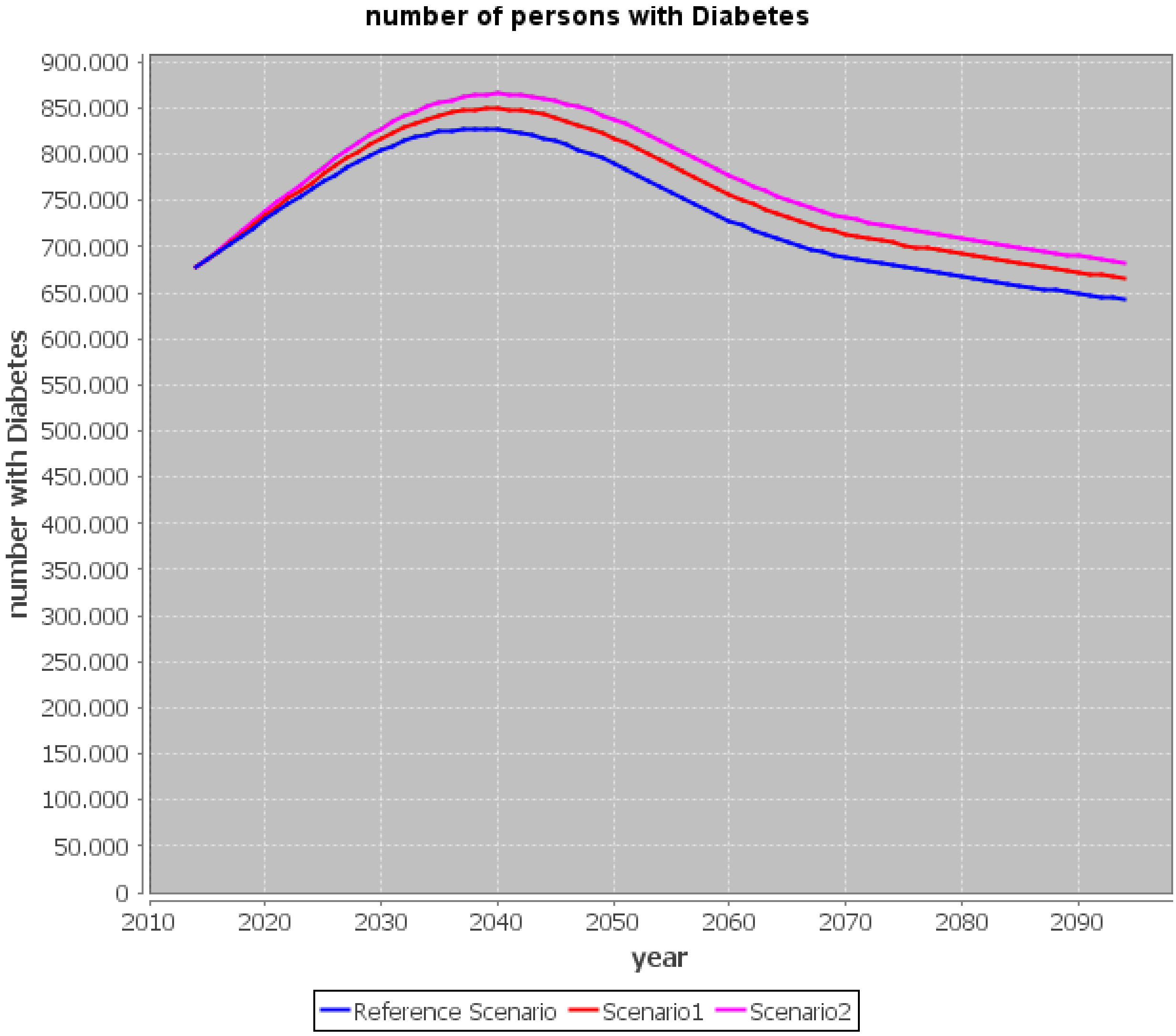

Figure 4.18: The number of persons with Diabetes in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for smoking"), and scenerio 2 (100% in healthiest smoking category), for the Netherlands, base year 2010

Finally, effects on health care spending are shown in Figure 4.19. The figure shows the difference (as a percentage of 2014 health care expenditure) in health spending for an intervention scenario compared to a scenario that is extrapolating spending based on 2014 prevalence. In the intervention scenarios a lower smoking prevalence results in different levels of spending (and less smoking-related diseases). The figure shows the effects on total spending and on the costs of smoking-related disease and all other diseases separately. The costs of care for smoking related diseases decline, and the costs of all other diseases increase. It can be seen that initial savings peak about 5 years after the reference year, while a break-even point would be obtained in 21 years. Over the entire period, health care expenditures increase with 7.4% in the intervention scenario compared to the reference scenario. The latter difference was calculated by adding undiscounted spending over the entire time horizon, weighing costs in each period equally. Figure 4.20 shows the difference in health spending for a cohort of 50-years old in euros rather than percentages. In this cohort of elder people, savings are more pronounced than in the total population and the break-even point is further into the future.

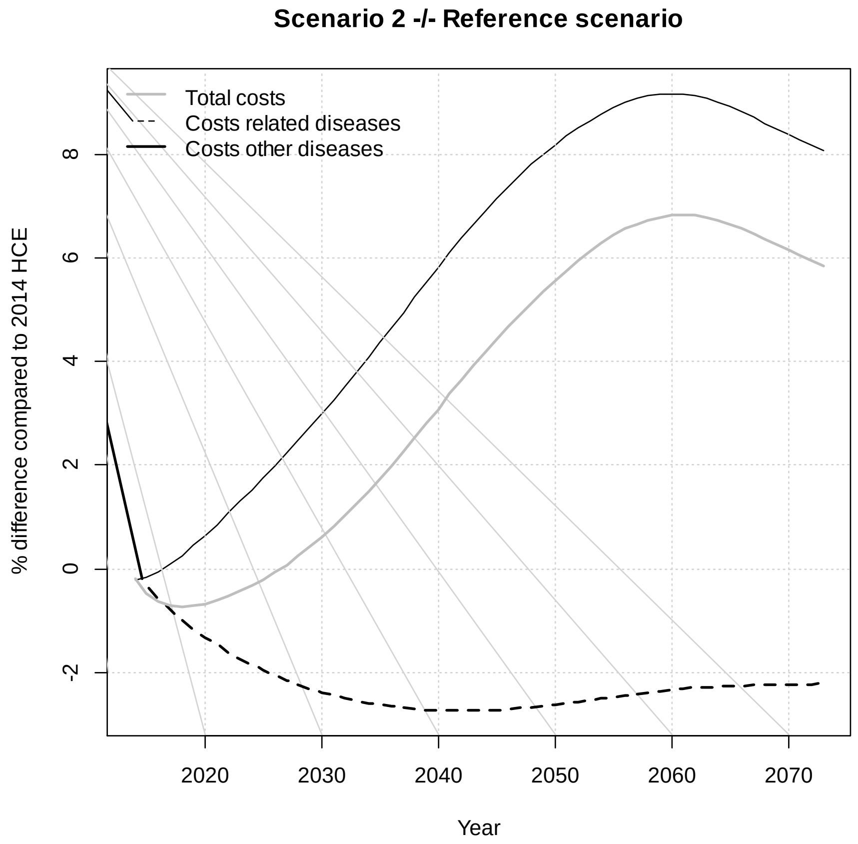

Figure 4.19: Changes in health spending when everyone quits smoking in current population

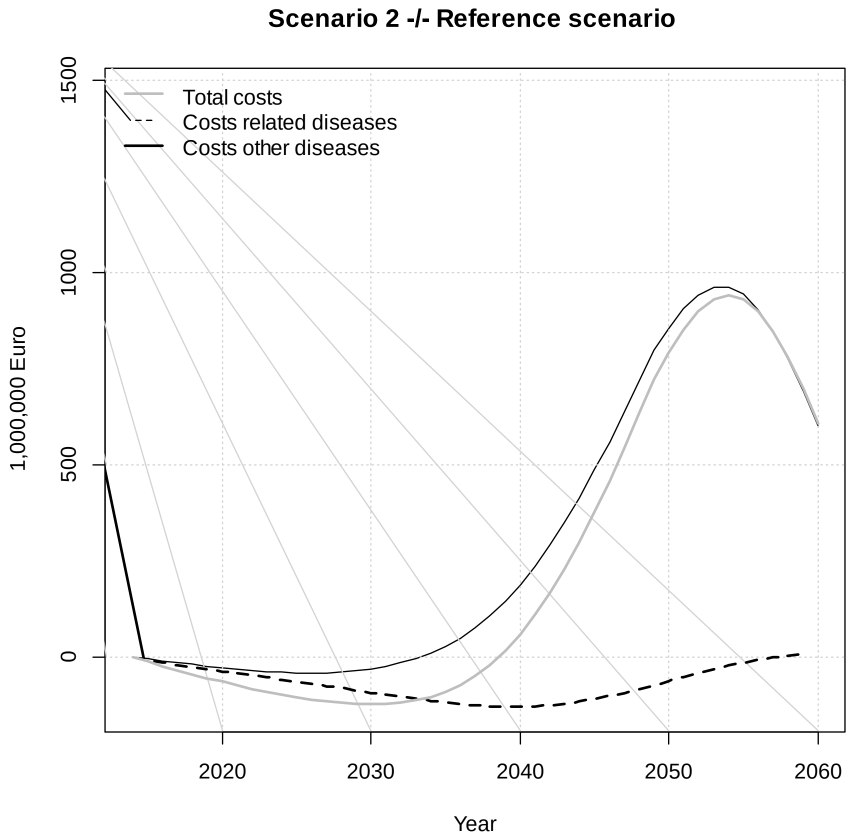

Figure 4.20: Changes in health spending when everyone quits smoking in current elderly population

For BMI, the pattern is more or less similar, but the effect on the total population numbers is smaller, resulting in less pronounced increases in diseases unrelated to BMI. Please note that in the figures below disease prevalence is expressed as a percentage, rather than in absolute numbers.

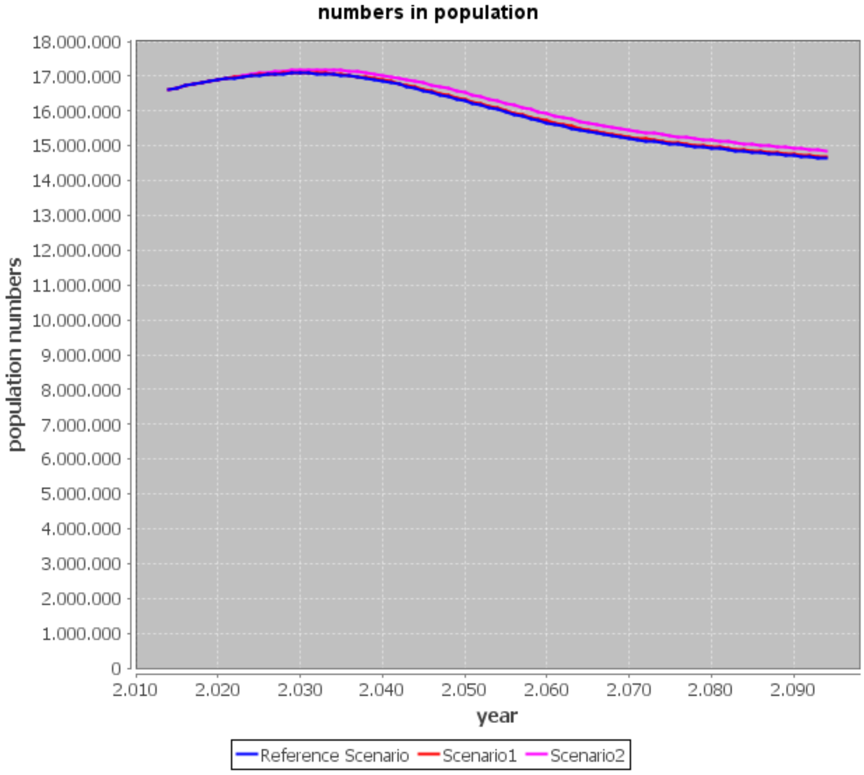

Figure 4.22: The total population in the reference scenario (lifestyle prevalence as observed), scenario 1 ("best of all for BMI"), and scenario 2 (100% in healthiest BMI category)

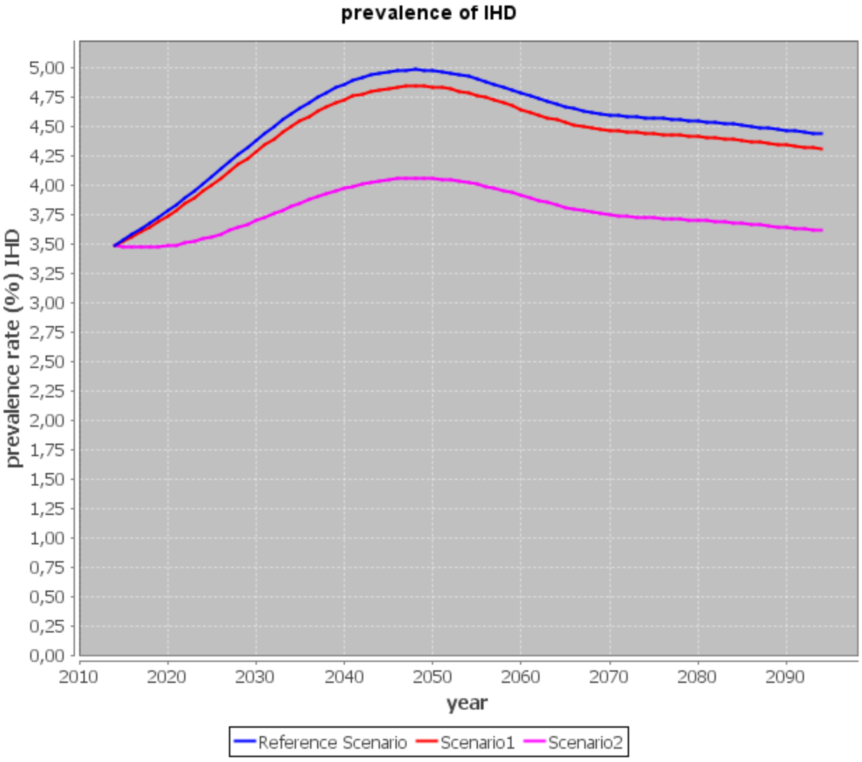

Figure 4.21 Effects of two scenarios concerning BMI (scenario 1, best of all and scenario 2, all in most healthy BMI category) on prevalence of ischemic heart disease, for the Netherlands, baseyear 2010.

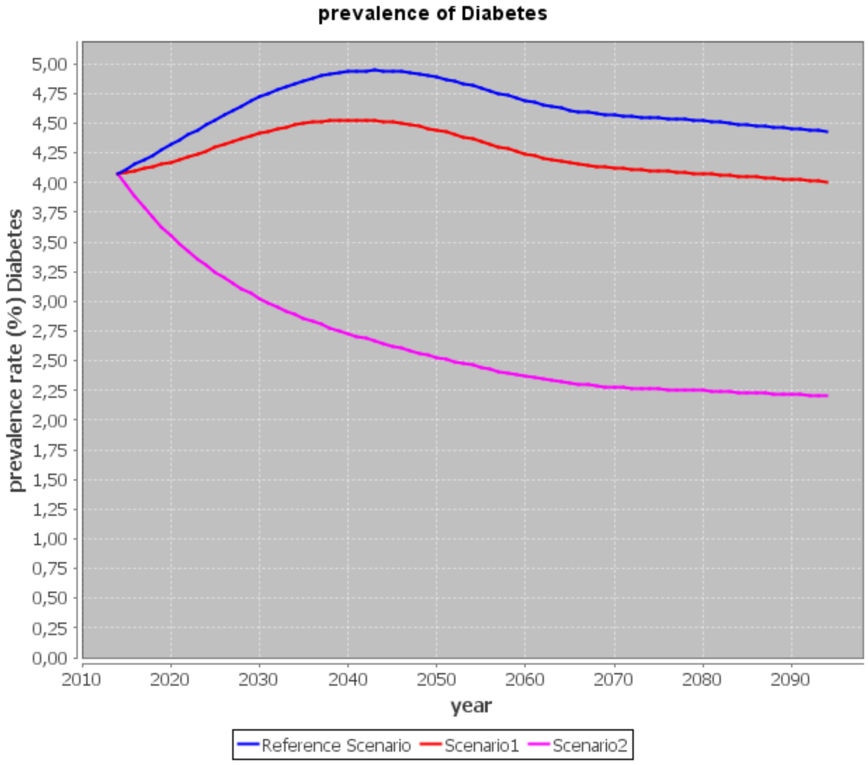

Figure 4.23: Effects of two scenarios concerning BMI (scenario 1, best of all and scenario 2, all in most healthy BMI category) on prevalence of diabetes, for the Netherlands, baseyear 2010.

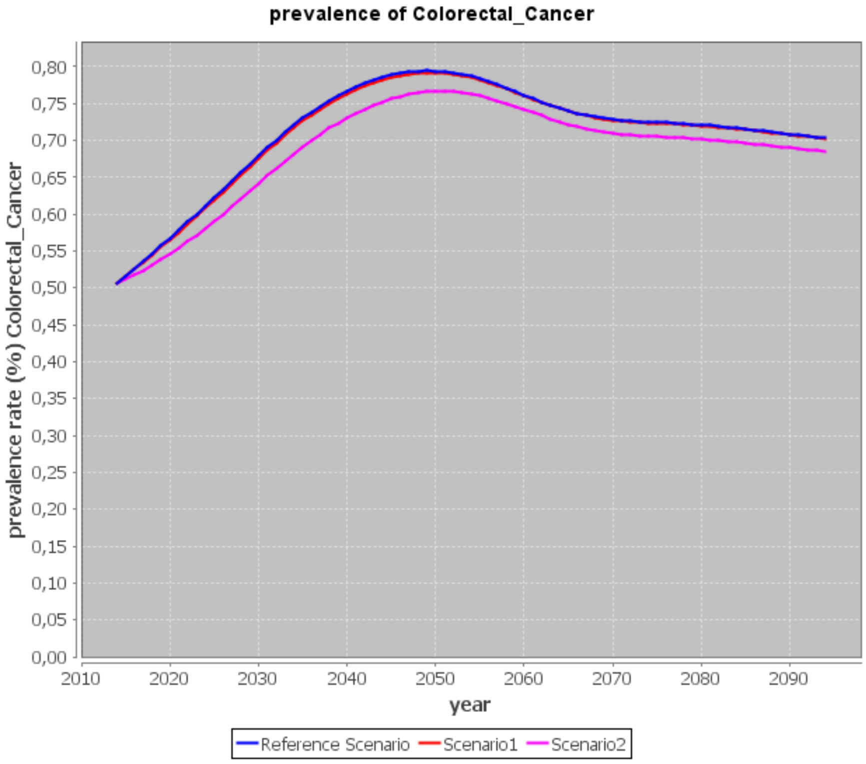

Figure 4.24: Effects of two scenarios concerning BMI (scenario 1, best of all and scenario 2, all in most healthy BMI category) on prevalence of colorectal cancer, for the Netherlands, baseyear 2010.

For lung cancer, in scenarios with improved BMI prevalence rises because of an older population.

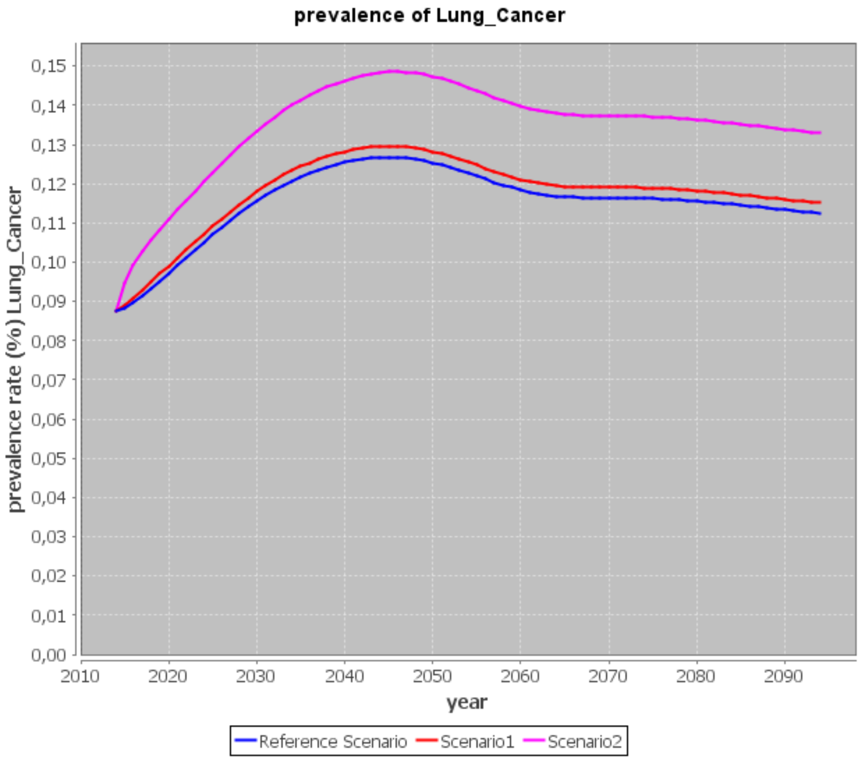

Figure 4.25: Effects of two scenarios concerning BMI (scenario 1, best of all and scenario 2, all in most healthy BMI category) on prevalence of lung cancer, for the Netherlands, baseyear 2010.

The net effect on health spending of an improved BMI in the population over time reflects first net savings and then increased costs. The latter are due to the population getting a longer life expectancy as a result of a healthier lifestyle which comes with an increase in diseases related to old age.

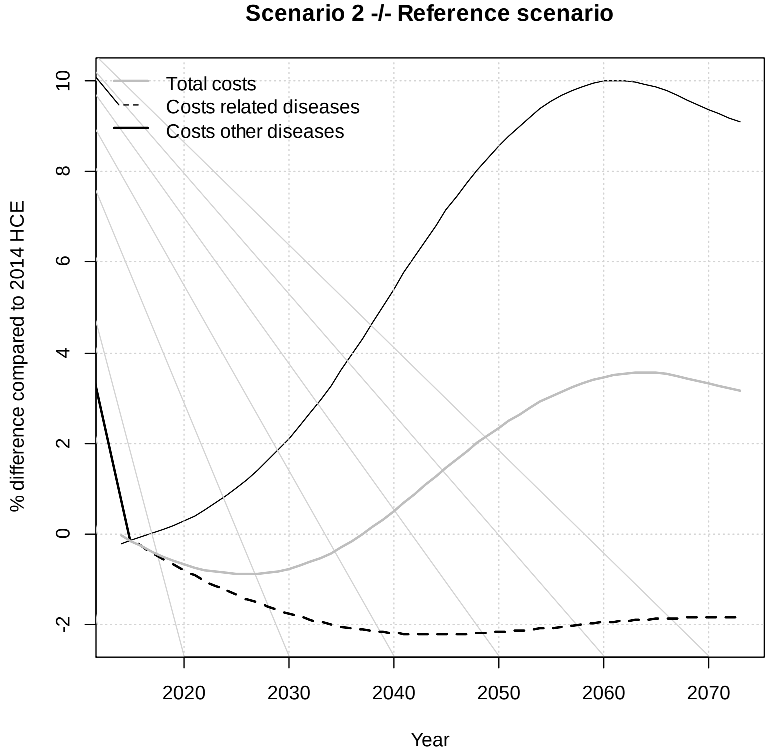

Figure 4.26 Changes in health spending "All positive" scenario compared to current practice, entire population, scenario concerning better BMI.

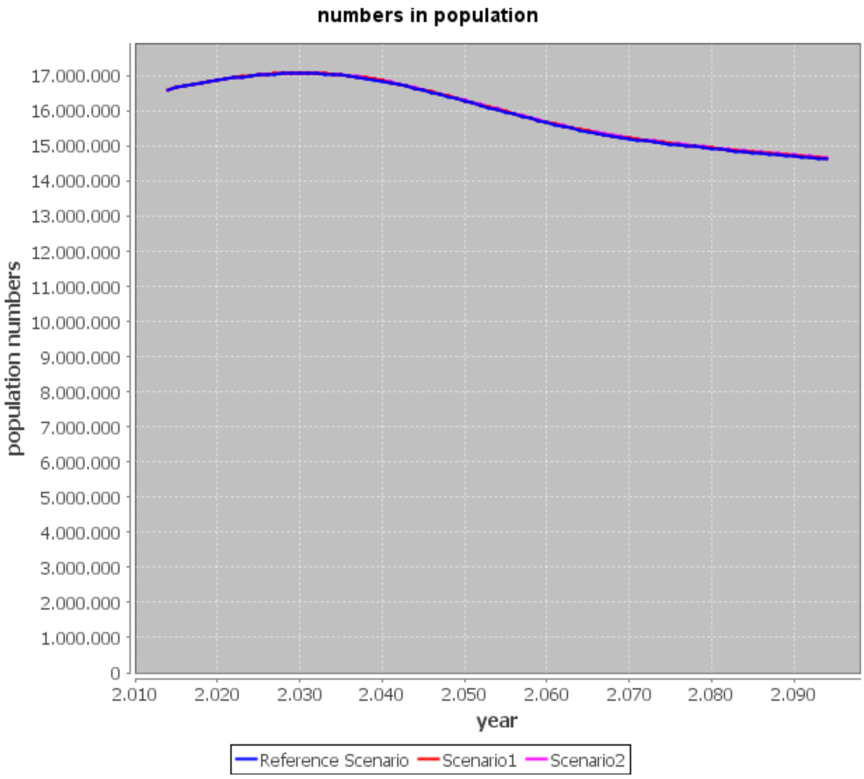

Figure 4.27: Effects of two alcohol use scenarios (scenario 1, best of all and scenario 2, all in most healthy alcohol use category) on total population numbers, for the Netherlands, baseyear 2010.

For alcohol use, the risks were smallest and as a result, effects on total population numbers from the scenarios were hardly perceptible. (Figure 4.31) The net effect on total spending showed savings for the entire time horizon. Hence, for alcohol the effects on life expectancy are too small to imply an increase in spending from costs in life years gained.

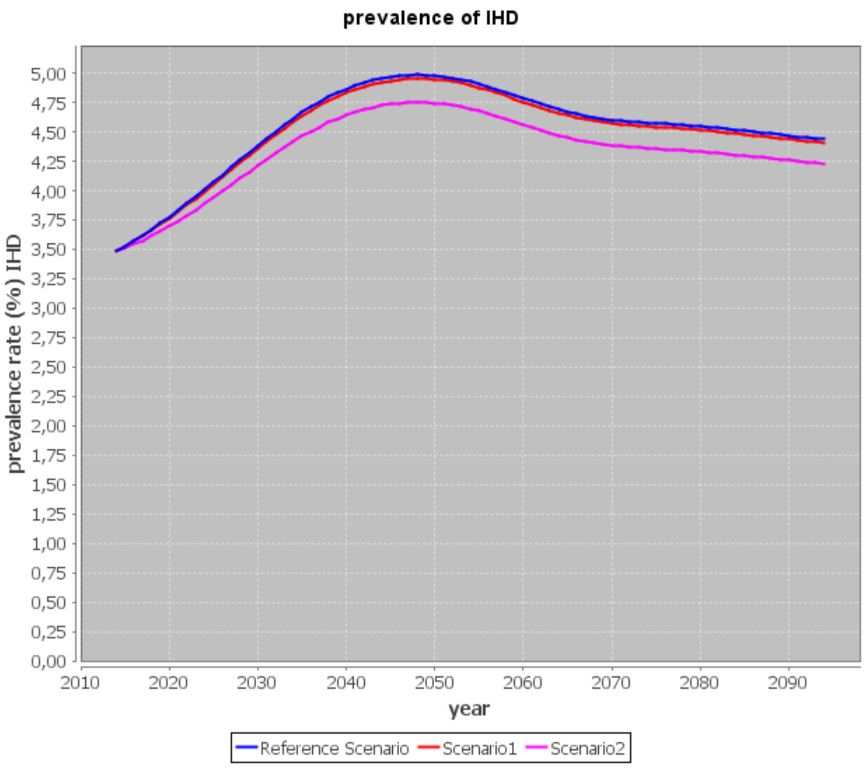

Figure 4.28: Effects of two alcohol use scenarios (scenario 1, best of all and scenario 2, all in most healthy alcohol use category) on prevalence of ischemic heart disease, for the Netherlands, baseyear 2010.

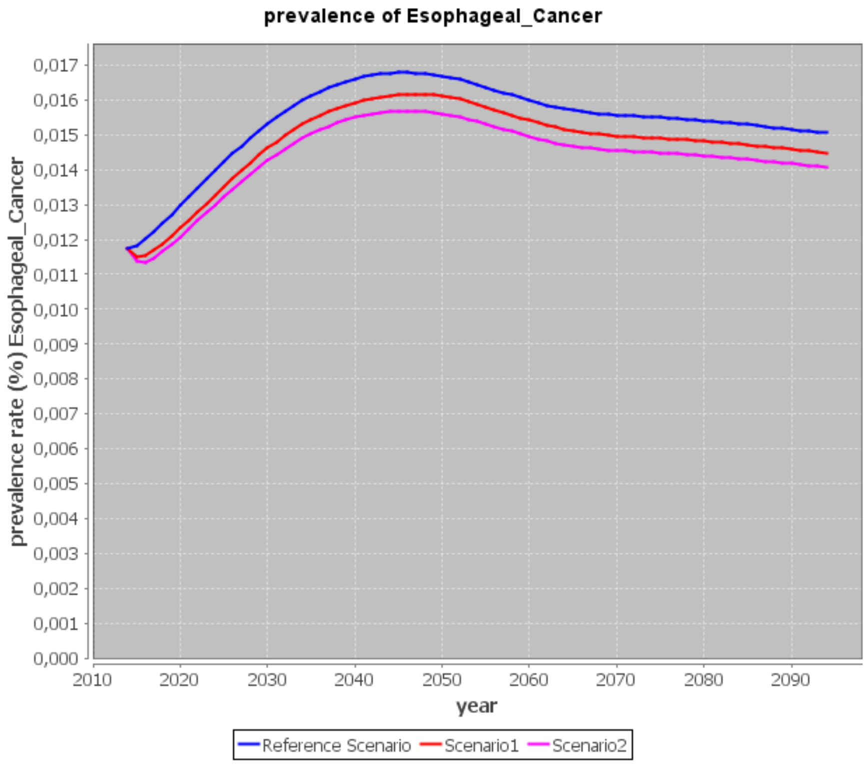

Figure 4.30: Effects of two alcohol use scenarios (scenario 1, best of all and scenario 2, all in most healthy alcohol use category) on prevalence of oesophagus cancer, for the Netherlands, baseyear 2010.

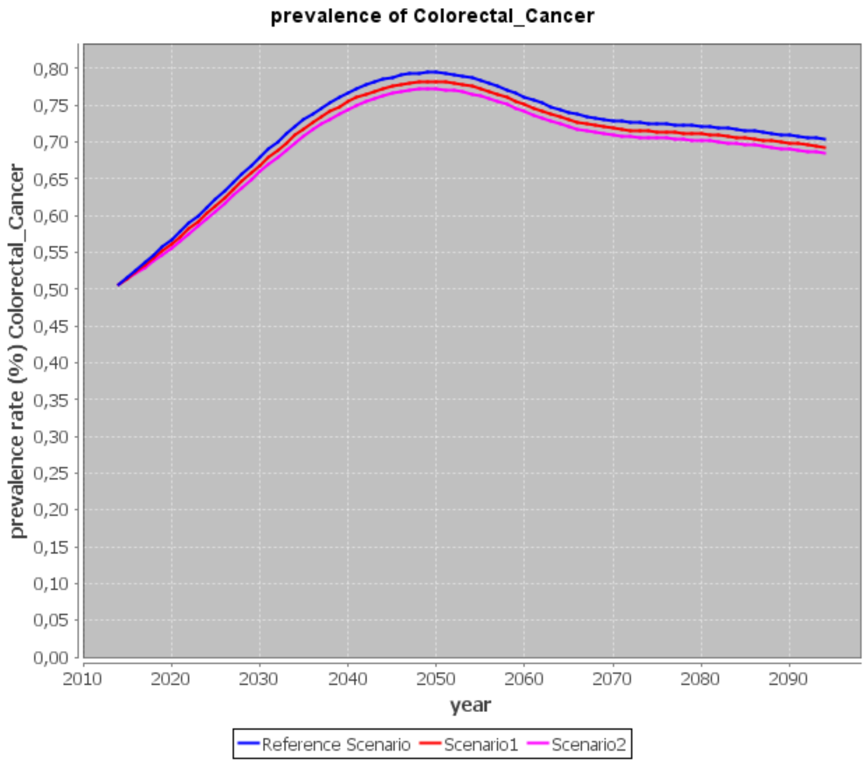

Figure 4.31: Effects of two alcohol use scenarios (scenario 1, best of all and scenario 2, all in most healthy alcohol use category) on prevalence of colorectal cancer, for the Netherlands, baseyear 2010.

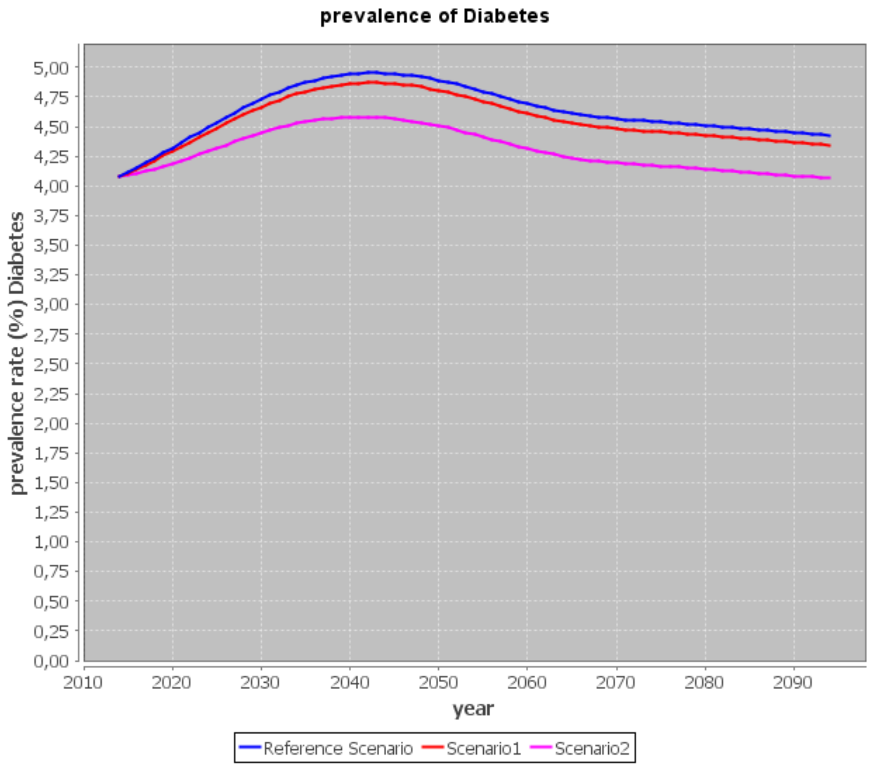

Figure 4.32: Effects of two alcohol use scenarios (scenario 1, best of all and scenario 2, all in most healthy alcohol use category) on prevalence of diabetes, for the Netherlands, baseyear 2010.

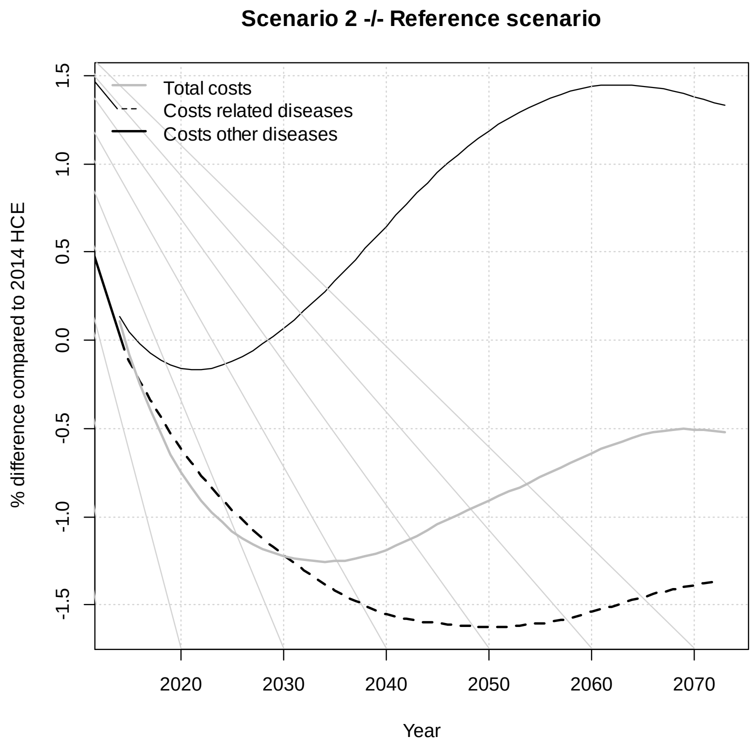

Figure 4.33: Changes in health spending "All positive" scenario compared to current practice, entire population, scenario concerning alcohol use.

Table 4.8 demonstrates the estimated years in which the savings in risk factor related disease costs equal the costs of all other diseases. For smoking this equals 2030 (assuming immediate risk reduction) or 2023 (assuming graduate risk reduction). For BMI this break-even point occurs later, because it has a smaller effect on mortality. Consequently, cost increases related to the greater use of care in longer lives are smaller. For alcohol small net savings result over the entire time horizon.

Table 4.8: Cost results of dynamic life table analysis

Table 4.9: Overview of results for disease specific scenarios on health spending

	BMI	Alcohol	Smoking (immediate risk reduction)	Smoking (gradual risk reduction)
"Best of all" scenario compared to current practice scenario				
% Costs	0.5	-0.1	1.8	4.0
Year in which savings in costs of risk factor related diseases equal additional costs of 'other diseases'	2036	NA*	2030	2023
Year in which cumulative savings in risk factor related diseases are outweighed by additional costs of 'other diseases'	2047	NA*	2039	2027
"All positive" scenario compared to current practice				
% Costs	1.4	-0.6	3.3	7.4
Year in which savings in additional costs of risk factor related diseases equal costs of 'other diseases'	2038	NA*	2027	2024
Year in which cumulative savings in risk factor related diseases are outweighed by additional costs of 'other diseases'	2049	NA*	2035	2029

*Savings in health care costs of alcohol related diseases outweigh the additional costs caused by other diseases in life years gained. No discounting was applied on future costs.

Conclusions concerning disease specific analyses

These additional analyses reinforce the notion that a healthier lifestyle (less smoking, a lower BMI or more sensible use of alcohol) will pay off in terms of substantial health benefits. Regarding health spending results are less clear-cut. Initially savings are obtained from a reduction in lifestyle related diseases. When the population then lives longer as a result of the healthier lifestyle, health spending may rise from increased spending on age related diseases. It depends both on the lifestyle and demography of the population as well as on methodological choices such as time horizon and possible discounting of future costs what is the overall net effect on spending.

5. Results in perspective, qualitative aspects

Analysing health system efficiency is complicated: the inputs and outputs / outcomes can be quantified in many different ways and the high number of variables that affect outcomes form a cluster of interacting factors related to individuals, their living environment and the health system at regional and national level.
The MACELI-study contributes to the knowledge on health systems efficiency and, more specifically, sheds a light on the interaction between life style, inputs and outcomes. The current chapter puts these results in perspective. It contains reflections on how the project outcomes fit in the overall complex picture of health system efficiency. Furthermore, we discuss some methodological problems and their consequences for the interpretation of the results.

5.1 What is health system efficiency?

Several definitions and types of efficiency are found in the literature, such as technical, productive and allocative efficiency (Palmer and Torgerson, 1999). Most definitions refer to 'value for money' or, more generally, can be traced back to the result of:

$$^{outcomes}/_{inputs}$$

These rather theoretical concepts raise questions about what this means in real life and for real health policy. First, we will focus on the numerator: what should health systems produce? Is production the only relevant objective of a health system?

What health systems produce (outputs)
Most European countries are facing challenges concerning health such as rising expenditures, aging populations, an increasing prevalence of chronic illnesses and economic recession. These challenges have accelerated the interest for the performance of the "health system". They have contributed to the perception of the national organization of everything related to health and healthcare as a 'system'. Many European countries made system reforms, and others are still in the middle of such reforms. Monitoring the functioning of health systems and evaluating the results of system reforms require an explication of goals or objectives of the system: what should the system produce? An obvious answer to that question is 'health'. However, this concept contains several dimensions and its definition is heavily debated. Moreover, health is not the only relevant output of health systems.

WHO, being one of the first explicitly conceptualizing the objectives of health systems distinguished the following key objectives (WHO, 2000):
- the level of population health,
- inequality in the distribution of health,
- the level of health system responsiveness,
- inequality in the distribution of responsiveness,
- fairness in financial contributions

CIHI uses a comparable concept for health system outcomes: "the improvement of the level and distribution of health in the population, the health system's responsiveness to the needs and demands of Canadians and value for money to ensure health system sustainability" (CIHI, 2013).
OECD defines outcomes of the system as health status "how healthy are the citizens of the OECD member states?". Health status is further operationalized as health conditions, human function and quality of life, life expectancy and well-being and mortality".

In contrast to these positively formulated outcomes, Donabedian (1980) distinguished five undesired outcomes in his standard work on quality of care, the 5ds: Dissatisfaction, Discomfort, Disability, Disease, Death.
Many other (slightly) different definitions can be found in the literature; however, providing an exhaustive overview is unnecessary to conclude that what health systems should produce covers several dimensions and that not only the mean value counts, but also the distribution of the outcomes over the population. For practical reasons, only a few outcomes of health systems were used in the MACELI-study: life expectancy, Healthy Life Years and life expectancy in good self-perceived health. Other relevant outcomes, such as disparities, responsiveness or financial protection were not incorporated.

What we put into the system (Inputs)
Measuring inputs seems more straightforward than measuring outputs. In the pathway from inputs to outputs, financial inputs form the first step. However, money first needs to be spend on inputs that can really be used to ‘produce’ healthcare or to create the conditions for this. Such inputs are for instance human resources, medical education, pharmaceuticals, materials, buildings, equipment, guidelines and information systems (Massoud et al. 2001). The system of health accounts provides an international definition and enables to compare countries with regard to their expenses on healthcare. This definition only include goods and services that are used up during the accounting period (year) and not capital goods. Including the latter one would complicate the comparison between countries.

Confounding variables
Although health systems contribute to the health of the population, it is important to keep in mind that besides the inputs and output that we discussed above many other (confounding) factors exist. A major share of the variation in health both within and between countries is determined by factors outside the health system. Such factors can roughly be grouped into biological (genetic) factors, economic, social, cultural and contextual factors. Some of these factors may have a direct effect on health (e.g. air pollution, traffic safety, drinking water facilities) while others affect health via behavior (cultural differences in eating and drinking habits, unemployment). Other factors, such as educational attainment have both direct and indirect effects. The economic situation of a country determines the amount of money that can be devoted to for example health, education and social security. Investments in other sectors than prevention and health care may contribute to the health of the population: for instance investments in housing, traffic, education and labor conditions. For our study, this means that an effect of confounding variables cannot be ruled out. Educational level and national income were included in our models. The results, as presented in 4.1, pointed out that their effects could not be ignored. Therefore, these variables were also included in the efficiency models.

5.2 The boundaries of the health system

When comparing health systems, an essential problem that needs to be solved is determining where the boundaries of health systems lie. Obviously, hospital care will be part of the health system in all reasonable definitions. However, a health system can be defined very broadly or very narrowly. A very narrow definition may just cover curative healthcare while a very broad definition may also include regulation of the use of seatbelts, water treatment and realization of bicycle tracks to promote physical exercise (Murray and Frank, 2000). Papanicolas and Smith (2012) stated that there is no right answer to the question where the boundaries of a health system lie in general, as “there are sound reasons for promoting the use of both wider and narrower boundaries. Narrow boundaries are better suited to holding stakeholders accountable, while broader boundaries are better for a more holistic understanding of determinants”. Figure 5.1 summarizes advantages and disadvantages of broad and narrow definitions.

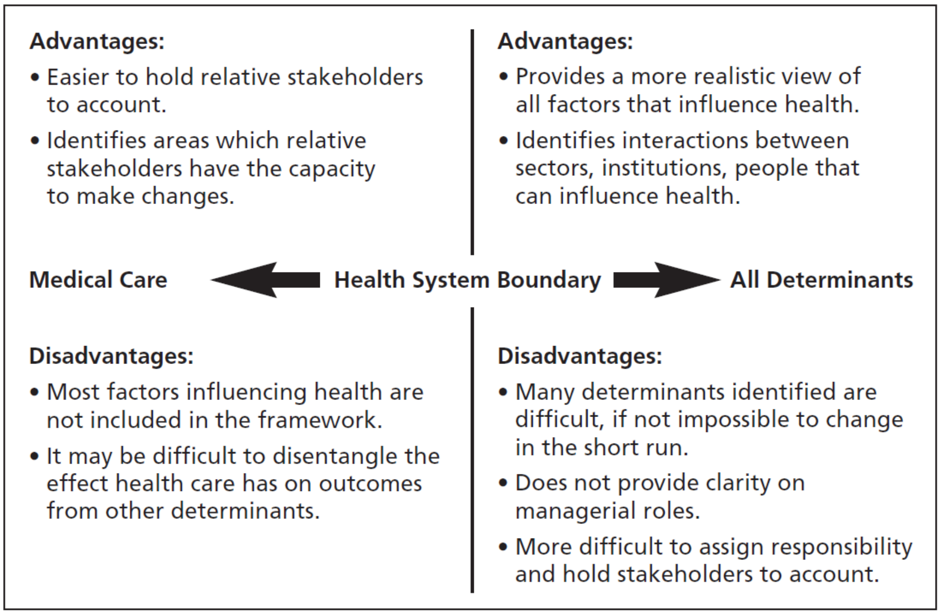

Figure 5.1: Performance measurement implications of setting health system boundaries (source: Papanicolas and Smith, 2012)

In our study, a relatively narrow definition was used. We focused on investments in curative care (hospital care, ambulatory care and outpatient medication, see 2.2) as input variable. Lifestyle behaviour was considered an exogenous variable in the model. The idea behind that approach is that the outcomes of health systems may differ because in one system suppliers have to deal with a population with an unhealthier lifestyle. Lifestyle behaviour is considered a factor beyond the reach of the health system. Difference in lifestyle may confound the relation between health care spending and health outcomes.

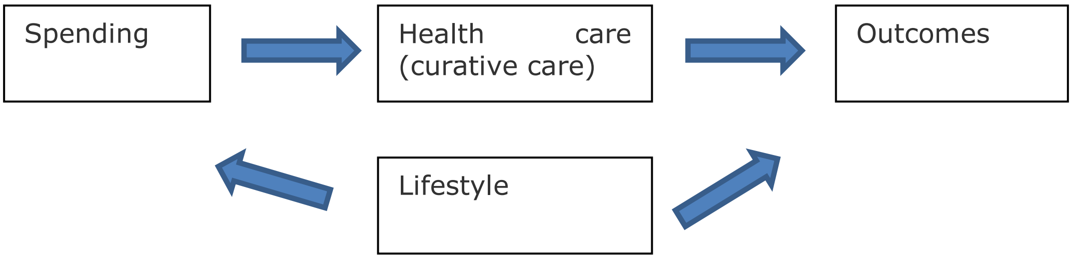

Figure 5.2: Schematic representation of the relations between spending, healthcare, life style and outcomes, using narrow definition of health system.

From a methodological point of view, this simplification of reality is practical and the only way to compare systems controlling for life style and necessary to model scenarios in which people would have a healthier life style. Nevertheless, from a public health policy perspective, it is very plausible to look at life style as an intermediary variable, rather than a confounder. In other words: one of the aims or instrumental goals of health systems is promoting a healthy life style. Not only public health workers, but also doctors work on prevention and may motivate their patients for instance, to stop smoking. Investments in prevention may contribute to better health outcomes. See Figure 5.3.

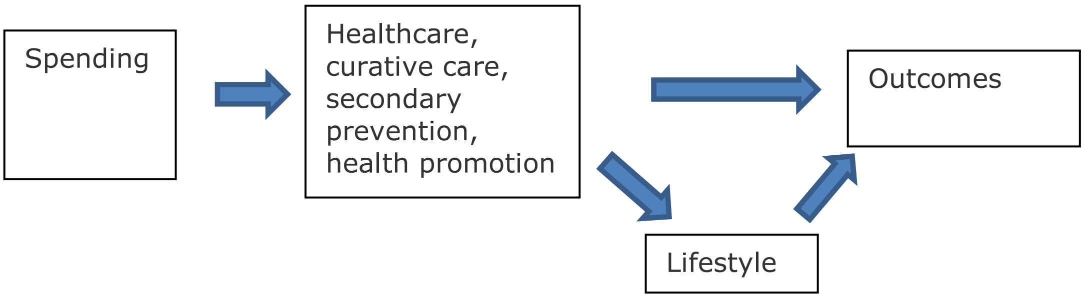

Figure 5.3: Schematic representation of the relations between spending, healthcare, prevention, life style and outcomes, using a broader definition of health system

Earlier (in 5.1) we discussed that health is influenced by much more factors than factors belonging to the health system. The same is true for spending. It seems logical that a higher need for care among the population results in a higher demand and so will generate more supply that needs to be financed. Although this is partly true, a quick look at health budgets of countries shows that the countries with the highest spending are not the countries with the most unhealthy population but rather the most wealthy countries (e.g. Norway, Switzerland). Like in other markets, demand will rise with supply as long as people can afford it. We will further discuss this in the next section.

Although the possibilities to influence life style could not be incorporated in the models, this topic is addressed in chapter 6, in which we provide an overview of options to effectively and efficiently influence life style.

5.3 Diminishing returns?

The relation between spending and health outcomes has often been characterized as one of diminishing marginal returns. This means that beyond a certain point, additional inputs produce lower returns. A typical example of such a relation is shown in figure 4 which was also shown in chapter 2. The figure shows a clear difference in outcomes between countries that spend 1000 euro per capita or less and those that spend 1500 euro or more. Above 1500 euro, however, extra euros invested do seem to be much less worth in terms of generating better outcomes. Norway for instance, shows a slightly lower life expectancy than Spain, while spending almost 50% more. Note that this figure is for life expectancy, for quality adjusted life expectancy (HLY and LEPGPH) the relations are less extreme but similar.

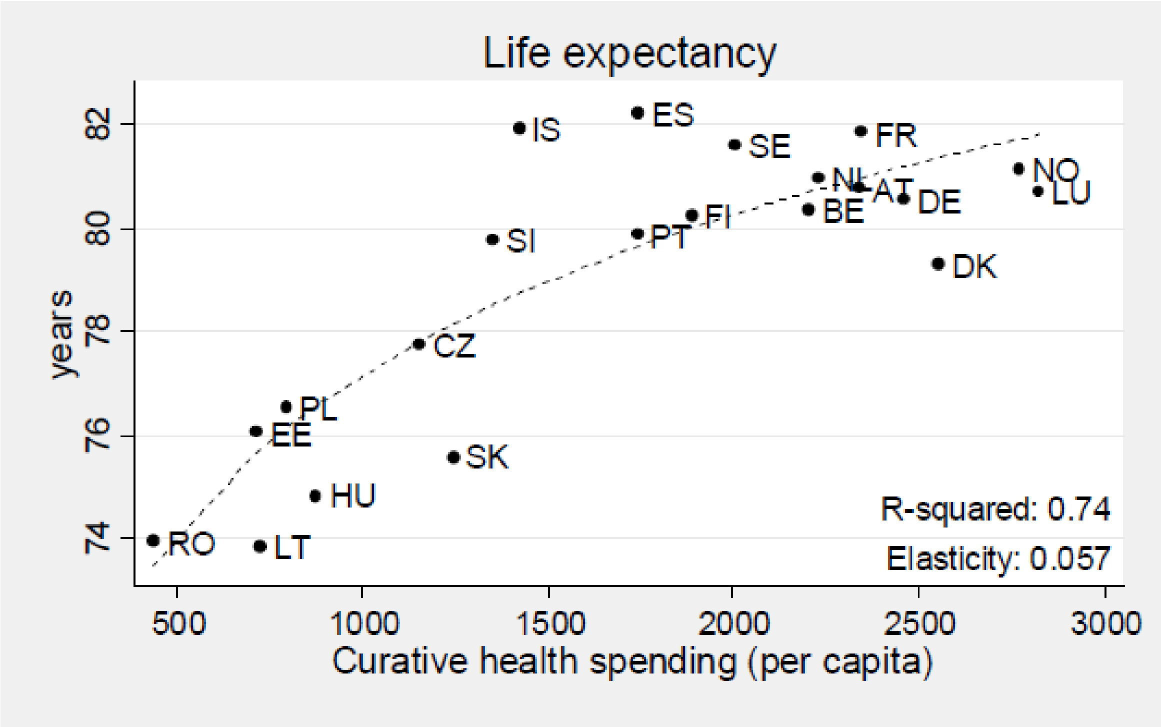

Figure 5.4: the association between curative spending and life expectancy

Also in relatively rich and wealthy countries, debates about cost containment are omnipresent. The 'law of diminishing returns' can be helpful in rationalizing discussions about prioritization, cost containment and, for instance, coverage of health insurance packages. Since every euro can only be spent once, in the policy debates questions arise like: "how much are we prepared to pay for a new treatment that adds two months to the life of a patient suffering from cancer?" Or, should interventions that add relatively little in terms of life years or quality of life be included in the basic health insurance package? Even when interventions and technologies already are very effective, both professions and industry will continue to innovate. Beyond a certain point, further improvement requires a larger and larger investment (Learmonth, 2006; Mold et al., 2010). Innovation in medical treatment and technology is essential, but also one of the main drivers of rising expenditures.

On the other hand, as discussed above, health systems have several aims. Some of these aims are important and do have a societal impact, but may not directly pay off in terms of life years or preventing disability. They offer for instance a reduction of dissatisfaction and discomfort. It seems plausible that a shift in focus of health policy will take place when the system is relatively well-functioning. A certain 'hierarchy of needs' not only applies to individuals but also to health systems: fighting infectious diseases and neonatal mortality pays off significantly in terms of life years. When such basic factors are relatively well organized, policy makers will start investing in responsiveness, patient experiences, privacy, better financial protection, etc. Although such things may not generate returns in terms of life years, they fulfil the expectations of tax payers and insured and they may contribute to well-being and satisfaction. In relation to figure 4, this means that countries that spend more than 1500 euros per capita are not necessarily wasting their money. Another possible explanation could be that a single "health production function" does not exist and countries are actually on different curves.

To summarize, the overall position in figures as displayed here provides little concrete indication for improving health policy but it may be a starting point to reflect on large budgetary posts and how this relates to the needs of the population.

5.4 Time lags.

Time lags exist between health spending and health outcomes, which means that current health may have been affected by past investments. The fact that our analyses are mainly based on cross sectional correlations is a methodological limitation that is discussed in chapter 7.

Especially when looking at developments of health systems efficiency over time, it is important to pay attention to the economic recession that started in 2008 and affected almost all European countries, although some more than others. A recent analysis of the OECD showed that until 2008, health expenditures rose in all European countries. After 20008, this changed dramatically: approximately one third of the countries had decreasing expenditures, another third still had increasing expenditures but this increase levelled off. Morgan and Astolfi (2014) suggested that for many countries, these decreasing expenditures resulted from drastic cut-backs in prevention. This conclusion might be criticized given the relatively low part of prevention expenditure related to lifestyle and the relatively low part of total expenditure related to prevention. Given these small budgets to start with, the overall impact of the recession on lifestyle prevention should not be exaggerated. Nevertheless when already small budgets are put under further pressure, effective policy may be seriously hampered.

In terms of the fraction outcomes/inputs as shown in 1.2, reductions in health expenditure result in a seemingly steep rise in health system efficiency. However, health expenditures respond much quicker to economic developments than e.g. life expectancy and cut-backs on prevention or other important parts of the system, may generate their adverse effects in the future.

5.5 Choice of outcome measures.

In this study, three outcome mesures were used: life expectancy, Healthy Life Years and life expectancy in good poor self-perceived health. As was mentioned under 5.1, this means that we only cover a part of the possible outputs of health systems. Partly, this was done for practical reasons: it would not be feasible to cover the full range of outcomes. Moreover, some outcomes show more variations in defintions and are more difficult to measure in a standardized way. In the terminology of Donabedian, our measures mainly refer to death, disease and disability. In terms of healthcare, the outcome measures represent results of curative care rather than long term and social care. Long term care focusses primarily on living with illness and/or disability rather than curing diseases and rather aims to contribute to quality of life and wellbeing rather than prolonging life.

5.6 Lifestyle clustering.

In the models presented in this study and in many epidemiological studies, BMI, smoking and alcohol are treated as independent risk factors. Such factors are not randomly spread over the population but often cluster within people and families (Schuit et al, 2002; Conry et al., 2011).

A study in England showed that the part of the population that engaged in multiple unhealthy behaviors decreased over time but this was mainly due to a decrease among the higher socio-economic groups and the higher educated. People with no qualifications were over five times as likely to engage in at least four unhealthy behaviours (smoking, excessive alcohol use, poor diet, and low levels of physical activity) (Buck and Frosini, 2012).
The Kings fund concluded that interventions to promote a healthy life style should adopt a more holistic approach, moving beyond policies in which the focus is on individual lifestyle risks one at a time, as this ignores how behaviours are actually distributed in the population (Buck and Frosini, 2012).

5.7 Conclusion.

The MACELI-study contributes to the knowledge about efficiency of health systems and the importance of life style in this relation. One main conclusion is that a healthy lifestyle clearly contributes to better health outcomes. The effect of lifestyle on health spending is less clear and seems to disappear when overall wealth (GDP per capita) is taken into account.
The study is a step in improving the comparison of efficiency between health systems. However, it should be kept in mind that the results only cover a limited part of relevant aims of health systems and that we did not touch upon major issues as responsiveness and disparities. Investments in the health system may generate valuable returns also when these cannot be expressed in terms of e.g. life expectancy. In this study, life style was treated as a factor to control for when comparing health systems. This was a pragmatic choice that enables us to compare efficiency taking into account intrinsic differences in population conditions between countries. The models contribute to existing knowledge by separating factors that can be more directly influenced by health services from public health factors.

6. Results in perspective, lifestyle and options for healthy lifestyle

6.1 Lifestyle behaviour in European countries.

We compiled data regarding alcohol consumption, smoking and overweight/obesity for each country, consisting of self-reported lifestyle behaviour. Figure 2.1 to Figure 2.3 summarize the information on lifestyle prevalence. Figure 2.1 shows the differences between countries in terms of BMI. We also considered differences between males and female. The percentage non-overweight (BMI<25) was lowest for females in Malta and Eastern European countries such as Croatia, Latvia, Lithuania and Hungary. For males, similar countries appeared at the bottom, except for Latvia. Much greater between-country variation was found for smoking.(Figure 2.3) The percentage never smoked varied between around 25% for males in Latvia and more than 75% for females in Portugal and the Czech Republic.

With regard to alcohol consumption (Figure 2.2), the data show large differences between males and females in most countries. The percentage of the population reporting heavy drinking was rather small. This is most probably, at least partly, due to underreporting. Since the data sources used to calculate Odds Ratios use similar questions based on self-reporting, the estimated prevalence is consistent with the Odds Ratios used for standardization.

The prevalences for each lifestyle variable and category were combined into 36 categories[5] indicating the prevalence of combined smoking, drinking and overweight.

6.2 Results literature review.

The literature review was performed to gain insight into the (cost)-effectiveness of interventions aimed at lifestyle improvement, which may provide lessons how to achieve lifestyle changes as hypothesized in the scenario analyses. The searches resulted in 69, 121 and 83 cost-effectiveness studies on interventions aiming at more healthy use of alcohol, at tobacco control and at a more healthy weight respectively. The studies were sorted on country and outcome measure, this could be done for 63 (alcohol), 112 (tobacco) and 75 studies (weight). For alcohol, 25 studies were performed in the US, while 14 were performed in other countries outside Europe and 2 were reviews. The European studies consisted of 11 studies presenting costs per QALY, DALY or life year gained, 2 cost studies and 9 presenting varying alcohol related outcomes, like number of drinks. For smoking 47 studies were performed in the US, while 14 were performed in other countries outside Europe and 3 were reviews. The European studies consisted of 38 studies presenting costs per QALY, DALY, or life year gained and 11 presenting costs per quitter. For overweight, 16 studies were performed in the US, while 18 were performed in other countries outside Europe and 6 were reviews. The European studies or reviews consisted of 20 studies presenting costs per QALY, DALY, or life year gained and 6 presenting costs per weight related outcome, like kg weight loss, or change in BMI.

All non-European studies were excluded, since organization and costs of interventions can be highly variable throughout different countries, due to differences in health care system.

Considering type of policy interventions, the majority concerned interventions aiming at individuals. These consisted of some form of counseling or a pharmacotherapeutical

[5] Combining 4 categories for alcohol use, 3 BMI categories and 3 categories for smoking generate 4*3*3=36 combination categories.

intervention or a combination of these. For smoking these were 33 studies. The remaining 16 studies consisted of evaluations of prevention (trying to prevent young people form starting to smoke), taxation, reimbursement of cessation help, smoking bans and mass media campaigns.
For overweight, all studies could be classified as evaluating individual based interventions, either medication (11 studies) or counseling (13 studies) or a combination of both (2 studies). 4 Studies aimed at children using counseling and could be considered preventive.

6.3 Spending on prevention.

Figure 6.4 and 6.5 underneath show expenditures on prevention and public health services across European countries, both in absolute terms and as a percentage of GDP. According to the definitions of the System of Health Accounts, the figures comprise services designed to enhance the health status of the population as distinct from the curative services, which repair health dysfunction (OECD, 2011). Typical services are vaccination campaigns and programmes. The following six functions are distinguished:

- Maternal and child health; family planning and counselling
- School health services
- Prevention of communicable diseases
- Prevention of non-communicable diseases
- Occupational health care
- All other miscellaneous public health services

Using the SHA definitions implies that care should be taken in interpreting these numbers, because several preventive services will be attributed to services under curative care. Differences in the definition and organization of prevention programmes between countries may affect these figures. Given that prevention aiming at a healthier lifestyle will only comprise a small percentage of these outlays, it is not really possible to link the numbers in the figures below to lifestyle outcomes for the different countries. To dive further into the issue, we tried to find information for each lifestyle factor separately.

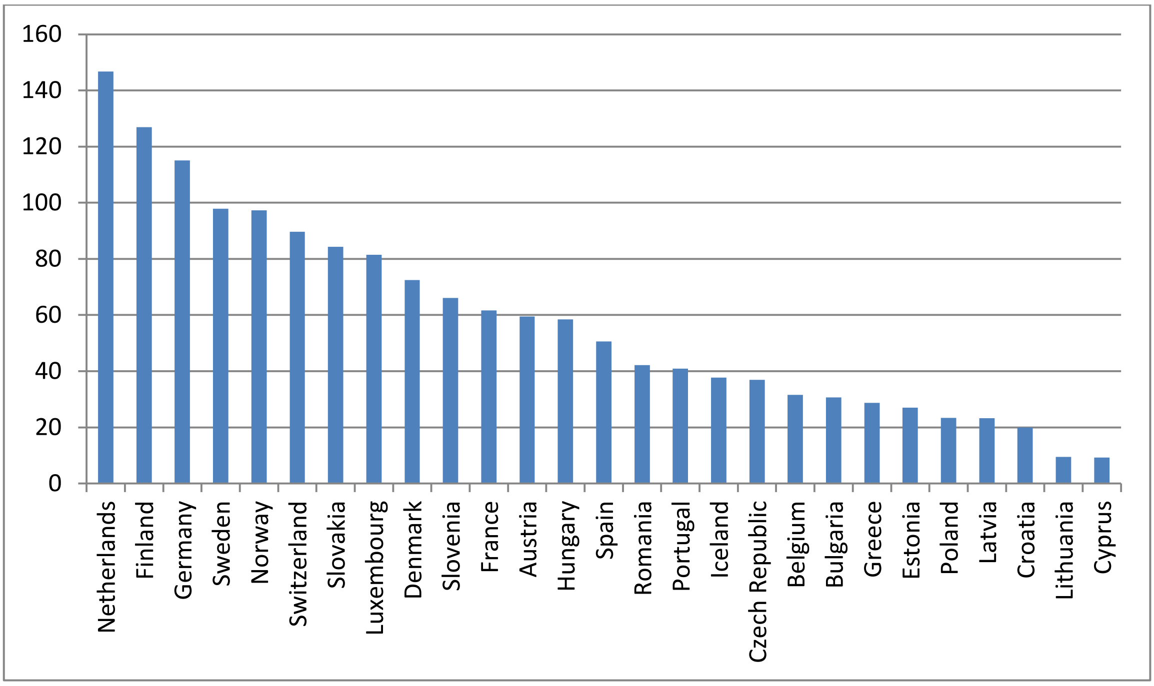

Figure 6.1: Expenditures on prevention and public health services per inhabitant in Purchasing Power Standard, 2010 or nearest year available (Source: Eurostat).

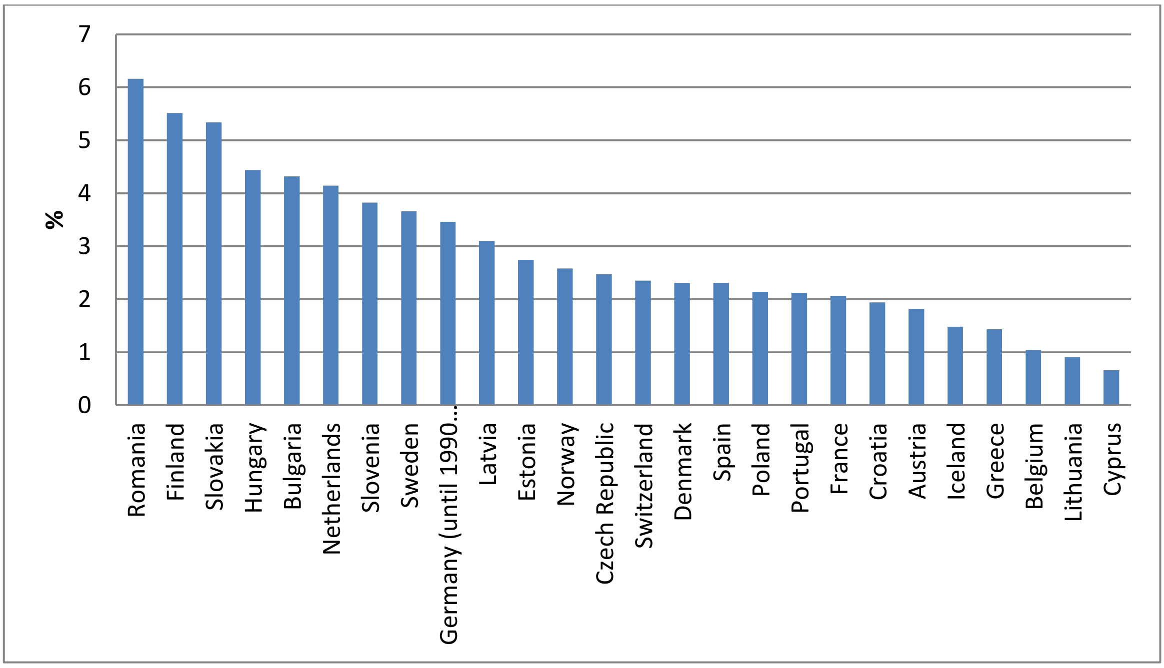

Figure 6.2: Expenditures on prevention and public health services as percentage of total health expenditures, 2010 or nearest year available (Source: Eurostat).

Tobacco

Information on tobacco policy can be found in reports by Joossens and Raw (Joossens 2006; Joossens 2014). These authors regularly investigated all policy regarding tobacco control in the EU member states and scored the stringency of these policies, using an elaborate score function. In total 100 points may be obtained for a country that applies all policy options considered in their most stringent form. The tables

below list the scores as obtained in 2013, together with information on budgets for tobacco control in the various countries (both based on Joossens 2014) and their smoking prevalence as obtained from the Eurobarometer data. By ordering and grouping countries according to policy score, budget for tobacco control, and smoking prevalence, it can be seen that some countries have low prevalence despite relatively mild policies (PT, NL), while others have stringent policies and low prevalence (ICE, NO). Information was not available for all countries. It must be stressed that estimating budgets in a consistent way was probably a very hard job. Also some countries with low prevalence are those for which we could not use the EuroBarometer, and had to rely on alternative sources.
In summary, these figures do given an indication, but in general no direct link exists between current spending and current smoking prevalence. What would be required to investigate this further would be a time series of budgets and a time series of prevalence, to see whether stringent policy pays off over time in terms of prevalence reductions.

Table 6.1: Countries ordered by policy score (source Joossens 2014, Eurobarometer 2012)

country	Score (100 max)	Budget ppp € 2012	Prevalence % 15+	former smokers
UK	74	0,35	27	26
IE	70	0,14	29	19
Ice	66	1,63	13,9	32
NO	61	0,45	16	
FR	57	0,12	28	24
ES	56	0,1	33	22
MT	56		27	17
FI	55	0,36	25	22
SE	48	0,06	13	30
HU	48	0,008	32	15
NL	47	0,09	24	31
BE	47	0,23	27	20
IT	46	0,21	24	13
DK	46	0,23	26	31
BG	46	na	36	16
RO	44	0,04	30	12
SI	43	0,06	28	19
EE	43	0,05	26	21
PL	43	0,01	32	20
LV	41	0,002	36	16
PT	41	na	23	15
HR	40	0,007		
SK	39	na	23	22
LU	37	0,06	27	22
LT	35	0,007	30	15
EL	35	na	40	16
CZ	34	na	29	17
DE	32	na	26	26
AT	31	0,06	33	20

Table 6.2: countries ordered by budget (source Joossens 2014, Eurobarometer 2012)

country	Score (max 100)	Budget ppp € 2012	Current Smokers (% 15+)	former smokers
Ice	66	1,63	13,9	32
NO	61	0,45	16	
FI	55	0,36	25	22
UK	74	0,35	27	26
BE	47	0,23	27	20
DK	46	0,23	26	31
IT	46	0,21	24	13
IE	70	0,14	29	19
FR	57	0,12	28	24
ES	56	0,1	33	22
NL	47	0,09	24	31
SE	48	0,06	13	30
SI	43	0,06	28	19
LU	37	0,06	27	22
AT	31	0,06	33	20
EE	43	0,05	26	21
RO	44	0,04	30	12
PL	43	0,01	32	20
HU	48	0,008	32	15
HR	40	0,007		
LT	35	0,007	30	15
LV	41	0,002	36	16
MT	56		27	17
BG	46	na	36	16
PT	41	na	23	15
SK	39	na	23	22
EL	35	na	40	16
CZ	34	na	29	17
DE	32	na	26	26

Table 6.3: countries ordered by smoking prevalence (source Joossens 2014, Eurobarometer 2012)

country	Score (max100)	Budget ppp € 2012	Current Smokers (% 15+)	former smokers
SE	48	0,06	13	30
Ice	66	1,63	13,9	32
NO	61	0,45	16	
PT	41	na	23	15
SK	39	na	23	22
NL	47	0,09	24	31
IT	46	0,21	24	13
FI	55	0,36	25	22
DK	46	0,23	26	31
EE	43	0,05	26	21
DE	32	na	26	26
UK	74	0,35	27	26
MT	56		27	17
BE	47	0,23	27	20
LU	37	0,06	27	22
FR	57	0,12	28	24
SI	43	0,06	28	19
IE	70	0,14	29	19
CZ	34	na	29	17
RO	44	0,04	30	12
LT	35	0,007	30	15
HU	48	0,008	32	15
PL	43	0,01	32	20
ES	56	0,1	33	22
AT	31	0,06	33	20
BG	46	na	36	16
LV	41	0,002	36	16
EL	35	na	40	16
HR	40	0,007		

Alcohol

For alcohol, GISAH from the WHO provides the most comprehensive overview of policy levels, while also at the EU level policy stringency is compared in several reports. Elaborate information may also be found on the site of EUROCARE. Three publications were found that did attach overall scores to rate policy stringency and completeness. The last of these was published in 2007 (Brand 2007) and covers 30 countries, among which several European. For EUROCARE, the original scale from the ECAS study was re-applied in 2005 and was calculated for a range of EU member states. Finally, as part of the Bridging the Gap project, a report on the same scale was published, presenting scores for 2005 for 30 European countries. (Karlsson & Österberg 2006, cf Eurocare.org or Karlsson and Osterberg 2007). This one seems most relevant for the current project. Its outcomes are presented in graphs in the publication and in separate factsheets for each country. Recent information on budgets for alcohol policy could not be discovered. Similar tables as for tobacco for this reason could not be constructed.

Overweight and obesity

For overweight and obesity, to the best of our knowledge neither a single policy stringency score for a sufficiently large range of countries, nor information on budgets was available. Similar tables as for tobacco for this reason could not be constructed.

Conclusions

Based on the limited information available, no firm conclusions can be drawn. The exception is tobacco policy, where the research by Joossen et al. has been performed for a range of years. While some countries seem to indicate success of a stringent policy (e.g. CIeland and Norway), others do not. What would be required to investigate this further would be a time series of budgets and a time series of prevalence, to see whether stringent policy pays off over time in terms of prevalence reductions.

Spending on prevention and public health contains multiple preventive policies and policy aiming at a healthier lifestyle is only a small part of these budgets. Especially in countries with smaller health care budgets, the majority of prevention budgets will be aiming at infectious diseases. This implies that adding such prevention spending in our main analyses would have confused rather than improved the analysis. To complicate matters further, many types of lifestyle policy will bring costs outside the prevention budget, e.g. when general practitioners advise their patients concerning lifestyle. Also, several types of policy are even outside the health care system, for example school programs, taxation and other types of regulation. This implies that several policy options have a financial burden that may quite often fall outside the definitions of the SHA. Given these difficulties, the approach taken in the current project, taking lifestyle as an exogenous variable and standardize for its possible impact on health care systems is a pragmatic solution. Using this approach, the most logic spending component to consider are curative care spending as we did, since these bear most direct relation to the health outcomes included in our analyses.

7. Discussion and policy implications

The previous two chapters already covered a large part of the discussion by putting our results into perspective and relating them to other literature regarding health system efficiency and research regarding a healthy lifestyle prevalence and its effects on health outcomes and health care spending. The current chapter adds to this and aims to summarize those smaller or larger methodological issues brought up during the expert panel validation phase and in discussions with our expert committee, which were not included in the two previous chapters. Furthermore it discusses possible policy implications, keeping in mind that the results should be interpreted with due caution.

Methodology

Health care efficiency in the literature

The efficiency of health systems concerns the relationship between the resources invested in health systems and the output produced by it. Commonly, population health is used as main output measure, because improving population health is considered the main goal of health services and health systems. Various studies have used international aggregated data to analyze the average relationship between health spending and population health across countries (e.g. Hitiris and Posnett, 1992; Cremieux et al., 1999; Berger and Messer, 2002; WHO, 2000; Or et al., 2005; Nixon and Ullman, 2006; Joumard et al., 2008; Heijink et al., 2013). These studies may clarify whether – on average - investments in health systems have an impact on population health at country level. Most studies found a positive association between health spending and population health (Van Baal et al., 2013). Few studies aimed to analyse the efficiency of health systems, which requires an additional step. Efficiency analyses are much more common in the organizational literature, for example to compare the efficiency of hospitals in a specific country (Jacobs et al., 2006; Hollingsworth, 2008). These studies are usually performed at the level of specific sectors (hospital care) rather than the entire health system. The goal of an efficiency analysis at system level would be to investigate whether individual countries reach the maximum level of population health they could achieve, given their level of health spending (Retzlaff-Roberts et al., 2004; Afonso and Aubyn, 2006; Joumard et al., 2008). It focuses on the part of the variation in health outcomes that cannot be explained by measures of health spending (and other confounders). Efficiency analysis involves several conceptual and analytical issues, as described below.

Methodological issues

Previous studies mostly used so-called health production functions representing the relationship between health outcomes and several input variables (determinants of health). Commonly, aggregate input measures and health outcome measures at country level were used. At first, the production function determines the average relation between health spending and health while controlling for potential confounders. Secondly, it can be used to estimate the efficiency of individual countries. To that purpose, (part of) the variation in health outcomes that cannot be explained by input variables, is attributed to inefficiency as explained below.

Methods to estimate efficiency of (health care) systems can be divided into two categories: parametric methods and non-parametric methods (for an overview see Jacobs et al., 2006; or for examples see Afonso and Aubyn, 2006 and Joumard, 2008). Both methods were used in this study.

Parametric methods use econometric techniques to estimate the parameters of the (production) function. The regression model generates estimates of the average relationship between health spending and health. Following, the residual, or: the

deviation of the observed data from the model prediction, is used as measure of efficiency. Some studies attributed the entire residual to inefficiency (equal to the Corrected Ordinary Least Squares (COLS) procedure). Others split the residual into two components: random error and inefficiency (Stochastic Frontier Analysis). Previous studies involving parametric methods most often used panel data models, because it creates more power in comparison to cross-sectional data.
Non-parametric methods do not impose any conditions on the functional form, but let the observed data determine the shape of the function. Data Envelopment Analysis (DEA) is the most widely used non-parametric technique. DEA considers the observations with the highest output/input ratio as efficient. It constructs an efficiency frontier through the efficient observations using linear programming ('enveloping the observations' in the dataset). The distance between the frontier and data points below the frontier is entirely attributed to inefficiency. One of the main disadvantages of the DEA approach is that it is sensible to outliers and may produce less reliable results for those countries with little peers (particularly relevant for small datasets). However, it does not rely on distributional assumptions as parametric models do.

Conceptual issues

As mentioned in the introduction, the conceptual issues refer to defining the inputs and outputs of the health system, defining the boundaries of the health system and identifying the external factors and time lags that affect the input-output relationship. Often, the output of health systems has been measured using (summary) measures of population health such as life expectancy, healthy life expectancy or infant mortality. Clearly, these output measures are affected by factors beyond the control of health systems such as the general wealth of the population, environmental factors, lifestyle, and demographics. In order to take this into account, most previous studies added these variables as covariates to their models (at aggregate level) (see e.g. Nixon and Ulmann, 2006; Joumard et al., 2008 and Van Baal et al., 2013).
A second issue is the 'unit of analysis' which should be identified in order to set the boundaries of the efficiency analysis (Jacobs et al., 2006). The unit of analysis should be able to convert resources into outputs and be comparable across the sample. In other words, the services included in the definition of the health system should be able to influence the population health measure that is used. In this study, our unit of analysis is the health system, based on the definitions of the System of Health Accounts framework. Using the SHA improves the comparability across countries, because the main aim of the SHA is to reach comparable definitions. However, this has not been reached yet for all services included in the accounts, for example regarding long-term care (OECD, 2012).
Finally, time plays an important role. Health outcomes may be affected both by current health care, but also by care in the past. Current spending will affect future health as well as current health. Similarly, past lifestyle behaviour may affect current levels of health and health spending. In a sensitivity analysis this was further investigated for smoking, the lifestyle factor for which the epidemiological evidence concerning risks of past behaviour is most elaborate (cf Apppendix 29.3).
Though authors have aimed to tackle the issues mentioned in the previous paragraph, no study using country level data was able to address all issues (Van Baal et al., 2013).

Methodological issues of the current study

Though the methods and data used in this report have been used in previous studies as described above, several specific issues need to mentioned.

First, the lifestyle data we used were self-reported and are likely to be subject to response heterogeneity (across populations), which may affect the lifestyle estimates. Furthermore, the Eurobarometer survey only irregularly contained lifestyle questions.

As a result, the reference year of the lifestyle data varied to some extent. This survey contained about 1500 observations per country, which is smaller than most national surveys (Bogdanovica et al., 2011). However, our pooling methods used the entire sample with country dummies, while allowing age patterns to differ across countries. By using such pooling techniques rather than stratified analyses for each country separately, we tried to account for the relatively small samples sizes in each country.
Notwithstanding the comments that could be made regarding the sampling method and especially the relatively small sample size of the Eurobarometer, it is the only survey that is both freely available at the level of individual data and contains information from all 28 EU member states. Once new and better data sources become available on all countries, a re-analysis is advisable.

Second, changes in health outcomes and health spending were based on individual level data. Previous studies showed that the level of health spending and changes in health spending at country level may be determined by factors that cannot be measured at individual level (Getzen, 2006). As a result, the impact of lifestyle measured at individual level may be outweighed by other factors at macro level. Such factors were discussed in the qualitative chapter. This project however aimed to analyse the effect of lifestyle factors and this could be done best by considering individual level data, since lifestyle does affect health mainly through individuals, with maybe the exception of alcohol use, which also has strong external effects.
The effect of the three different lifestyles was assumed to be multiplicative, in line with our estimates of odds ratios which were corrected for the other lifestyles. Prevalence was also assumed to be independent. It would have been better to account for clustering, using individual data. However, we could not do so, since we had to rely on separate survey rounds for the different lifestyle factors. To reliably estimate clustering would require a single survey covering all lifestyles investigated in the same questionnaire and with sufficient sample sizes.
Another problem with our estimates of odds ratios for smoking and overweight could be the limited age range covered by SHARE, which starts at age 50. However, younger people also have less disability, implying that possible overestimations of odds ratios for these groups contribute relatively little to the total standardized outcomes. We have added sensitivity analyses with a 50+ population for some scenarios. The SHARE survey data did not include all countries used in the entire study. In addition, a French survey was used for estimating odds ratios related to alcohol consumption. These showed better face validity than the odds ratios based on the original multi-country survey.
As opposed to spending, other variables could have been chosen for the measure of health care use. Literature shows examples using volumes, which avoids the price effect. We corrected for price differences by using purchasing power parities.
Our additional analyses are evaluating scenarios at the disease level. This highlights that disease specific information is worthwhile next to the aggregate outcome measures in our main analyses. Note however, that these analyses use a different type of scenarios. The standardization in the main analysis aims to correct for the possible disturbing effect of lifestyle on health system efficiency estimates. In contrast, the additional analyses evaluate hypothetical lifestyle scenarios to evaluate the potential future effects of changes in lifestyle. In combination with information on costs and effects of interventions, such analyses may support lifestyle policy by evaluating more realistic policy scenarios and informing about long term health gains, effects on health care spending and cost-effectiveness. In theory, one could perform the main analysis also by using a disease specific model. However, this would require data on prevalence of chronic diseases, on disease related quality of life, and on health care spending specific to diseases for all countries. Such data is not yet available.

Another point of critique may regard the amount of standardization. One could argue that countries should be made more comparable by also standardizing for the demographic distribution (age and gender distribution in the populations). This particularly refers to the health spending data, since the summary measures of population health take into account the population distribution. Health spending was standardized for differences in disability and life expectancy between countries. Unfortunately, more detailed age-specific health spending data, which would enable a more elaborate standardization, are unavailable at this moment.

The DYNAMO HIA model used for the standardization was developed as part of a EU FP7 grant and publicly available. Its development was carefully documented and published in peer reviewed journals. The conceptual model was validated through an expert committee, while the code and implementation were tested. A limitation is that the model version used for the current report was not independently validated. Since the main structure of the model was not altered, this is not of major concern. An important further validation effort would be to compare model results to external data concerning the EHIS health outcomes in different lifestyle categories. For instance we could compare the model predictions regarding perceived quality of life and life expectancy for smoking, overweight, moderate drinkers in Germany to an external data source with the same information. This is a research project in itself, and it is expected that such data are not readily available.

The research aimed to include information on all 29 countries. The Eurobarometer however did not contain information on Iceland, Norway and Croatia, while some of our other data sources covered smaller subsets of countries. This is shown in tables. While in the analyses, we used proxy countries to impute for missing data, still we had too little information to reliably estimate health spending corrected for lifestyle in about 9 countries. Croatia, Norway and Iceland were included in the calculations, but not included in the figures, since the lifestyle information was based on different sources and hence the results were considered to be less well comparable to those of the other countries.

Changes in lifestyle translate into health benefits. Part of these benefits only occur after quite some time, since lifestyle related diseases later in life may be prevented by a healthy lifestyle at young age. The current cross sectional analyses directly related current lifestyle to current health outcomes, which is inherent in cross sectional research, but a clear limitation. It partly explains that some of the odds ratios found may appear low, especially for alcohol use. Nevertheless, for most alcohol related diseases it is current and not past exposure that has the strongest relation to current health outcomes.

Smoking behaviour 20 years ago may affect current health outcomes. Partly this is accounted for by including former smoking as a separate category in the analyses. For overweight and alcohol however, such a category could not be distinguished. The extent to which old lifestyle behaviour for alcohol and overweight would influence the health spending-health relationship *at macro-level*, and cross-country differences therein, is unclear. Also, the literature does not provide any evidence on this. The additional analyses showed that changing the assumptions about the timing of smoking cessation in the most extreme case could create a difference of about 3 years in terms of smoking standardized life expectancy.

Time lags also exist between health spending and health outcomes, which means that current health may have been affected by past investments. Our panel data allow going back to 2004, but not further, given important changes in data definitions in that year.

It might be argued that countries with a long history of healthy lifestyle should perform better than countries which just shifted, and that our analyses cannot distinguish between these two types of countries. So some of the countries that show relatively poor health outcomes given their level of expenditure could be countries with unhealthy lifestyles in the past, which were not sufficiently corrected for by our current standardization methods. Note that this only is a problem when trends do differ a lot among the different countries. Further research into this issue would need comparable historic lifestyle data, and additional sources for estimating odds ratios. The SHARE data base might provide the latter type of data, since it contains now 4 waves now.

Recommendations

Given these discussion points, the main implication that arises from the current research is that better data concerning lifestyle and its effects on quality of life would be highly desirable. For the type of research as currently undertaken international comparability and easy access is highly relevant. The EHIS initiative in this respect is very important.

In the meantime, new Eurobarometers surveys covering several lifestyle factors in one survey would enable to investigate clustering. If the survey would also include some quality of life outcomes that would be even better, providing an additional source, next to SHARE for investigating the relation between lifestyle and aggregate self-reported health outcomes. Such outcomes could be the two EHIS items, self-reported health and disability, or could cover a short quality of life questionnaire, like the SF12, or EQ5D. While larger sample sizes and more elaborate surveys are of course preferred, added value in the currently existing surveys is also worthwhile.

In addition, regarding data, the ongoing initiatives to provide more consistent and complete information on health care spending are very worthwhile. Having spending information at the level of conditions would be very interesting and enable disease specific modeling which is useful for the evaluation of policy scenarios.

Policy implications

The finding that a better lifestyle does improve health outcomes considerably is not new, but worthwhile stressing once more. Also, the results of the review regarding cost-effectiveness underline the potential value of investing in primary prevention. Our analyses suggest that improved lifestyles do not strongly influence the demand for health care, with small consequences of better lifestyle behaviour on health spending in the long run, while health benefits might be substantial. However, these results were obtained in a cross sectional analysis. The additional analyses with a dynamic model show that for some lifestyles, especially smoking, the positive effect on life expectancy could rise the average age of the population, which contributes to health care spending. Definite conclusions would require such analyses in more than a single country and use of more realistic intervention scenarios. Given that upfront investments are needed to implement cost effective interventions, further research could investigate ways to incentive these investments.

The relatively small impact of lifestyle on countries relative efficiency indicates that probably the three factors investigated are not of major influence regarding countries' relative health system efficiency. Still, a more elaborate analysis with data on very long time periods would be needed to support more definite conclusions. The data requirements of such a study are large however and we question whether the foreseen additional insights are worth the efforts required. A more fruitful approach in terms of policy support would be to support countries in their lifestyle policy strategy. Scenarios as in our additional analyses and especially more realistic policy scenarios on concrete interventions and regulations may inform countries about the foreseen health gains from lifestyle policy in relation to short term and long term effects on health care spending, in line with the Australian ACE project.

Our modelling analyses further show that improvements in lifestyles have a bigger impact on healthy life expectancy than on life expectancy: people not only live longer but also longer in good health. This may have implications for the policy debate on the statutory retirement age in EU age as living longer in good health might also facilitate longer working lives.

Conclusion

This report presents the findings of the MACELI study on health spending and health outcomes across European countries. The study shows substantial variation in (curative) health spending and population health between European countries. On average, countries that spend more on health care also have a healthier population. In addition, the efficiency analysis shows some variation between countries in terms of the "health spending-health" ratio (cost-effectiveness). These results are similar to Joumard et al. (2008) who presented figures for life expectancy using panel data. However, given the strong association between GDP per capita and health spending, the effect of health spending disappears after adjusting for GDP per capita and it becomes unclear whether health spending has an independent effect on health outcomes. As a result, the current cross-sectional data do not allow drawing far-reaching conclusions.

We also found observable differences in lifestyle prevalence between countries. Individual level data analysis shows an effect of lifestyle behaviour on self-reported health. Furthermore, unhealthy lifestyles are associated with greater mortality risk, which is included in the DYNAMO-HIA simulations. That is, differences in lifestyle potentially affect countries health system efficiency scores through several pathways.
The modelling results reflect these relationships and hypothetical healthier scenarios (through changes in lifestyle) generated higher healthy life expectancy at country level. At the same time, differences in health spending remained largely unchanged in all scenarios. This implies, within the limits of our study design, that lifestyle is not an important confounder when one wants to estimate the impact of health spending on population health.
As a result, the average "health spending-health" ratio improved as a result in the scenarios with a healthier lifestyle. However, the differences in efficiency between countries did not change substantially after adjustment for lifestyle.
The scenarios ignored the costs and difficulties of obtaining the improved lifestyle. This precludes current firm policy implications. Our literature review underlines that potentially cost-effective policy options are available and the clear potential for efficient prevention policy.

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9. Appendix

9.1 Health system cost effectiveness results with total health spending

This Appendix includes results of the unadjusted analyses including total health spending instead of curative care spending (so similar to section 4.1).

Table 9.1: Elasticity of population health to total health spending, GDP per capita and education

	LE	HLY	LEGPH
Basic model (t=2010)			
Total health spending	0.042*	-0.068	0.047
GDP per capita	0.011	0.166	0.059
Education	-0.037	-0.093	0.030
N_i	29	29	29
R-squared	0.80	0.28	0.60
Panel data model (t=2004-2011)			
Total health spending	0.036***	-0.042	0.094***
GDP per capita	-0.035***	0.019	-0.065***
Education	0.118***	0.207***	0.192***
N_{it}	231	208	208

P-value of null hypothesis of no effect. *p<0.10; **p<0.05; ***p<0.01

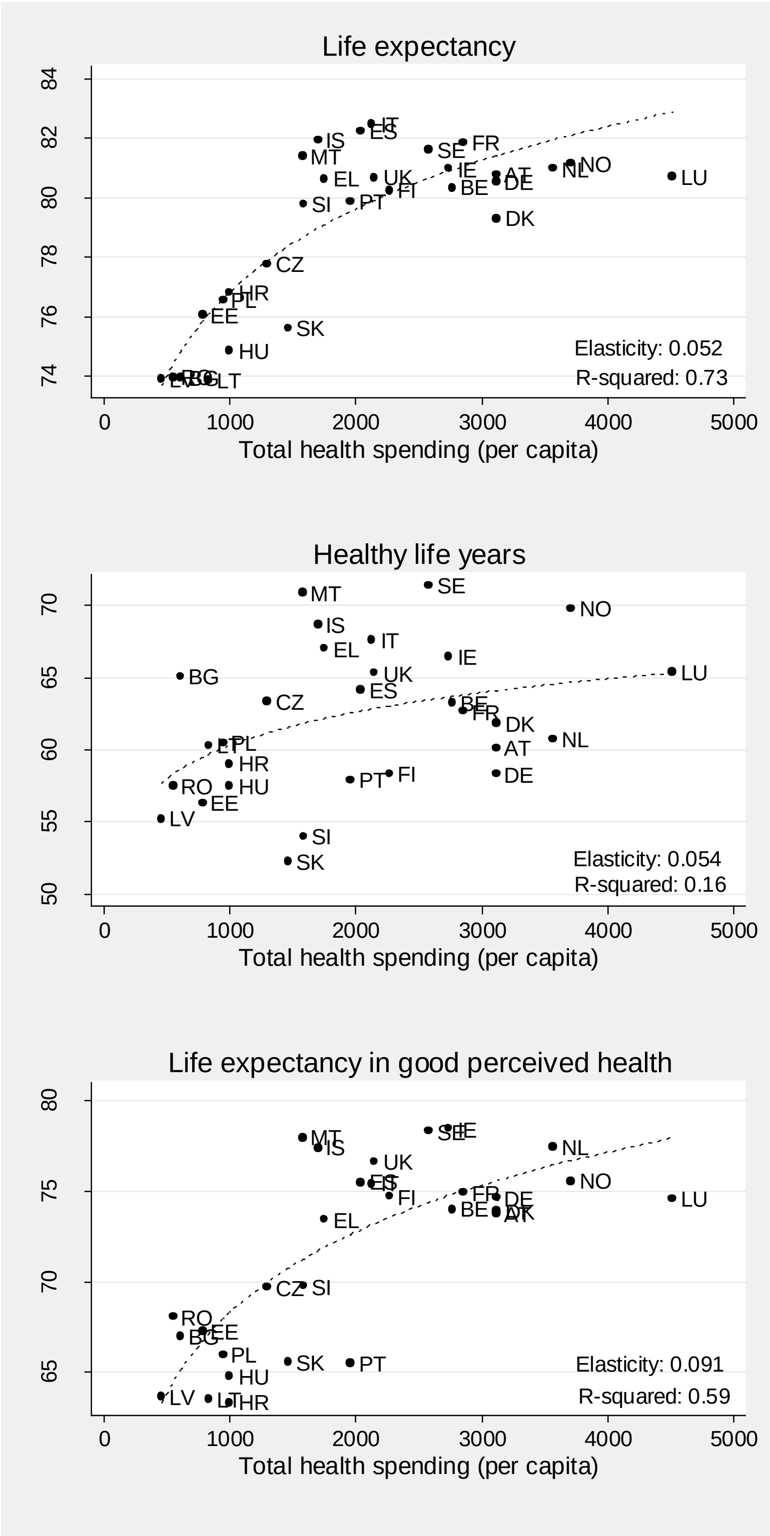

*Figure 9.1**:** The association between total health spending and population health*

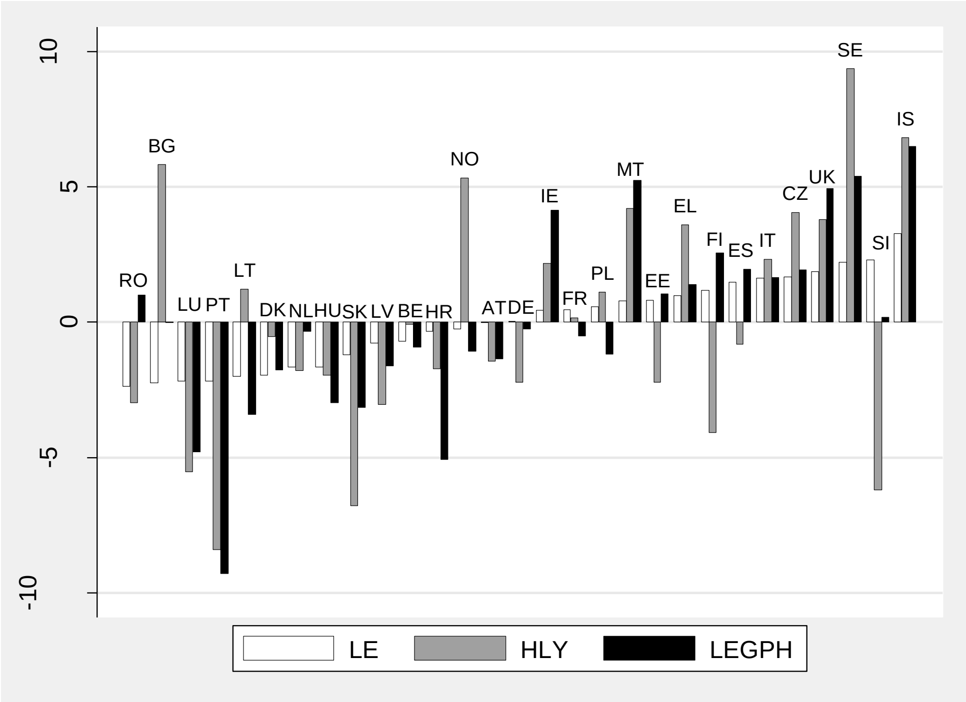

Figure 9.2: Output oriented-technical efficiency estimated by parametric analyses using total health spending

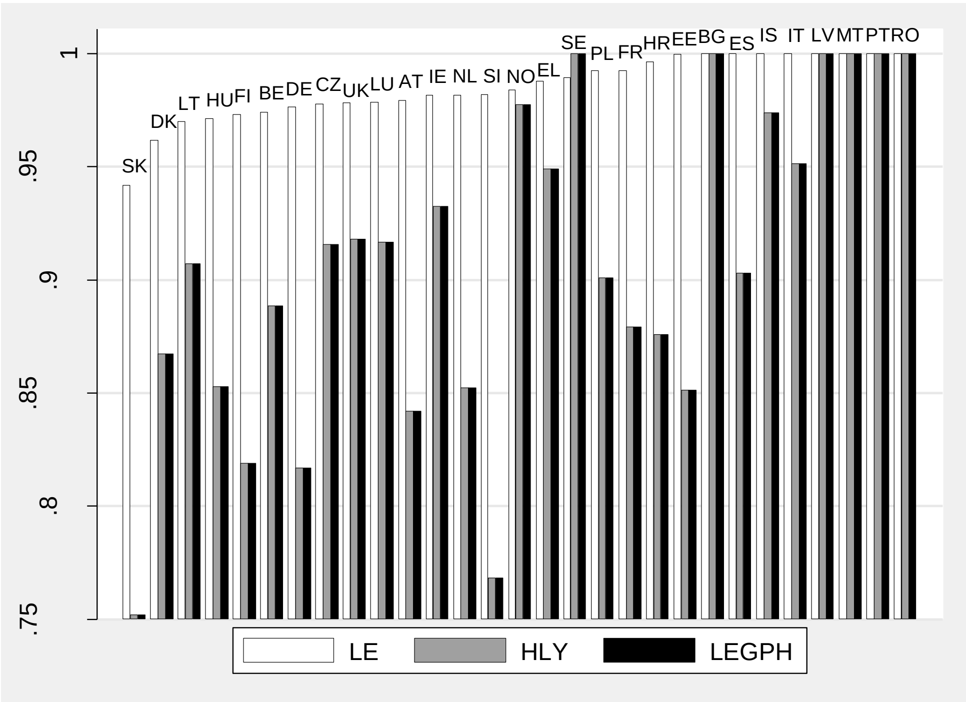

Figure 9.3: Output oriented technical efficiency estimated by DEA using total health spending

9.2 Baseline values for health spending and population health

Country	LE	LEGPH	HLY	THCE (€)
Austria	80.45	58.33	59.60	2339.46
Belgium	80.05	60.53	62.94	2201.44
Bulgaria	73.81	54.95	64.76	545.69
Croatia	76.65	58.37	58.37	893.62
Cyprus	81.15	59.73	64.79	1347.31
Czech Republic	77.57	53.44	62.69	1152.76
Denmark	79.24	58.30	60.74	2553.83
Estonia	75.98	46.11	55.61	713.23
Finland	80.01	58.11	57.08	1886.45
France	81.34	56.91	62.17	2344.18
Germany	80.49	56.25	61.98	2460.08
Greece	80.50	62.65	66.65	1512.03
Hungary	74.54	47.35	56.93	875.28
Iceland	81.92	67.68	67.68	1420.94
Ireland	80.81	67.12	65.96	1979.02
Italy	82.13	58.16	67.33	1825.51
Latvia	72.90	41.63	54.19	382.25
Lithuania	73.16	45.15	59.63	722.84
Malta	80.71	56.10	70.49	1358.14
Netherlands	80.77	64.30	60.40	2229.57
Norway	81.03	68.47	68.47	2769.94
Poland	76.30	48.32	59.76	793.41
Portugal	79.93	43.83	57.23	1739.92
Romania	73.77	54.96	57.08	436.00
Slovakia	75.46	50.57	51.68	1243.42
Slovenia	79.52	50.30	52.81	1351.82
Spain	82.04	59.97	63.59	1743.38
Sweden	81.52	66.71	70.80	2004.78
United Kingdom	80.40	65.07	64.50	1802.92

9.3 Additional scenarios with different odds ratios for former smokers

Figure 9.4 shows the level of health spending and life expectancy at country level in two additional scenarios using our cross sectional main analysis, but with different odds ratios for former smokers. In a first variant, all former smokers in a country are assumed to be long-term quitters. This assumes the healthiest starting situation in each country. For such already very healthy countries (all former smokers quit long ago) less room exists for improvement when moving to a scenario with a healthier lifestyle (in this case scenario 1, "best of all"). So, the increase in life expectancy in this variant is smaller than in the main analysis. In a second variant, all former smokers are assumed to be recent stoppers. This assumes the least healthy starting situation in each country. For these not so healthy countries (all former smokers just quitted) more room exists for improvement when moving to a scenario with a healthier lifestyle (in this case scenario 1). So, the increase in life expectancy in this variant is larger than in the main analysis. These variants serve to investigate further the possible effects of differences between countries in their lifestyle history. The figure shows that changing the assumptions about the timing of smoking cessation in the most extreme case can create a difference of about 3 years in terms of smoking standardized life expectancy. Keeping in mind that especially the blue line reflects an unrealistic and extreme situation in which all former smokers have just quitted very recently, this is of the same order of magnitude as the actual effect sizes in our main analyses.

The actual results for scenario 1 show a line that lies in between these two extremes. In the actual results, the relative risks used for former smoker are the same for all countries and in between those of current and never smokers. Thus, we implicitly assume that the average time since cessation in former smokers as included in these relative risks properly reflects that in all countries included in the analyses. Note, however, that the current analyses do use age specific data on percentages of current and former smokers as well as age specific risks. This partly helps to distinguish between countries which made a recent transition towards less smoking and countries that have always had a low smoking prevalence. The latter will be characterized by relatively few former smokers at all ages, while the former will have large numbers of former smokers in the age groups that used to smoke until recently. Using more detailed information would of course be preferable. However, as can be seen from the current figure, while countries do move upward (life expectancy differs about 3 years in terms of life expectancy) changes on the x-axis are much smaller. A more detailed analysis would not only require detailed information on time since cessation of former smokers in all countries, but also disease specific information, since risks of former smokers and how these change with time since cessation vary per disease. (Hoogenveen et al. 2008) This would complicate the analysis considerably.

Similar analyses for alcohol and overweight were not possible, because risks were only estimated for current lifestyles, in contrast to smoking. Also, existing epidemiological studies do not provide much information on the magnitude of time-lag effects for these risk factors.

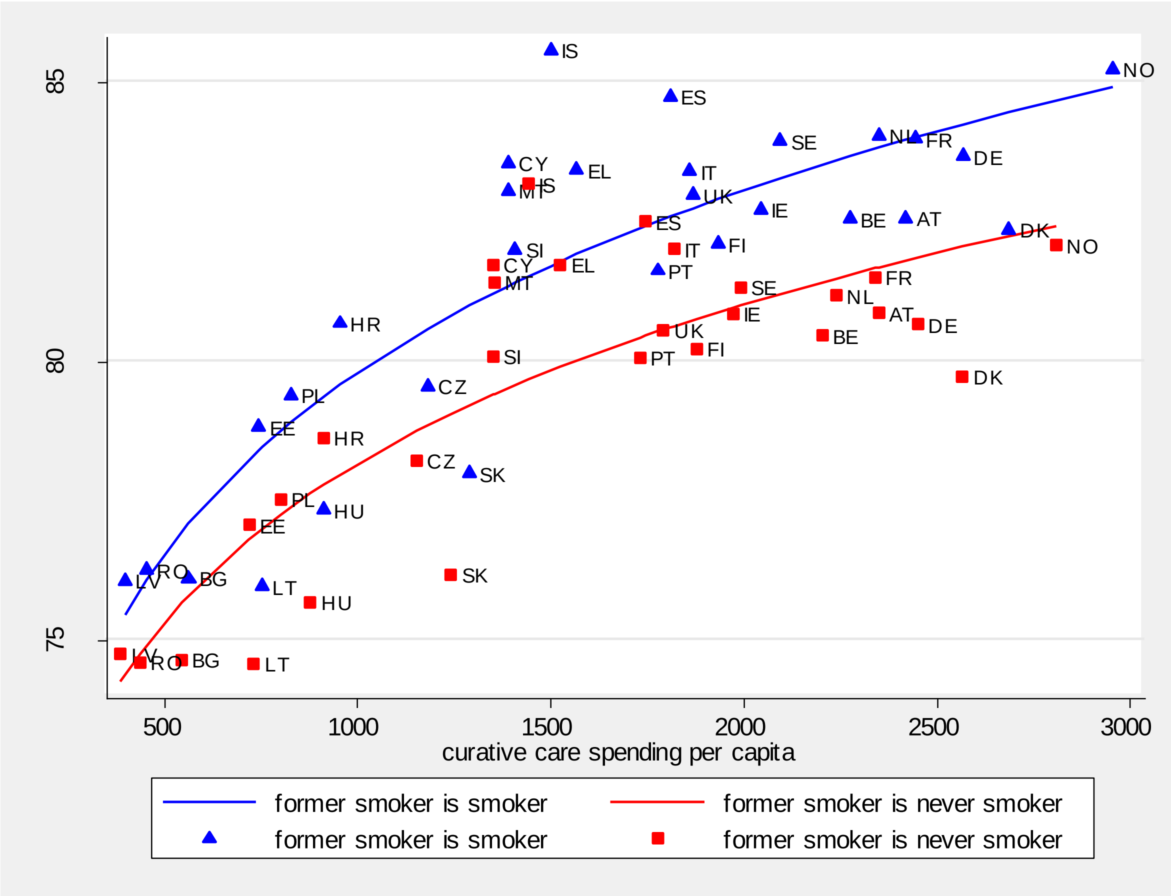

Figure 9.4: The association between curative care spending and life expectancy in the additional scenario with different odds ratios for former smokers

9.4 Details on data analysis for lifestyle

Survey questions BMI

For overweight, the questions used were obtained from Eurobarometer survey no.64.3 from November-December 2005 (http://www.gesis.org/).

We used the following questions to calculate BMI:

- Q.D5 How tall are you (in cm) without shoes?
- Q.D6 How much do you weigh (in kg) without shoes and clothes?

BMI was calculated using the basic formula (BMI=weight (in kg)/height (in m)²). Following, three BMI classes were distinguished:

- BMI<25
- BMI>=25 & BMI<30 (overweight)
- BMI>=30 (obesity)

Survey questions tobacco

For tobacco, the question used were from Eurobarometer survey no 77.1 from February-March 2012 (http://www.gesis.org/).

The question used was:

- EB72.3 QD1: "Regarding smoking cigarettes, cigars or a pipe, which of the following applies to you?" (READ OUT – ONE ANSWER ONLY)

The following answer categories were available: You currently smoke (M); You used to smoke but you have stopped; You have never smoked; DK (do not know/no answer). Category DK was left out for the final pooled analysis, but is presented in the raw data. It was assumed these were proportionally distributed over the other three categories. Finally, three categories remained:

- never smokers
- former smokers
- current smokers

Survey questions alcohol

For alcohol, we used the questions from the Eurobarometer survey no 72.3, which was conducted in October 2009 (http://www.gesis.org/).

Questions used were:

- QC1a: During the past 12 months, did you drink any alcoholic beverage (beer, wine, sprits, cider or other local beverages)?
  Answers: Yes; No; DK/Refusal
- QC1c: Did you drink any alcoholic beverages (beer, wine, spirits, cider or other local beverages) in the last 30 days?
  Answers: Yes; No; DK/Refusal.
- QC2: In the last 30 days, how many times did you drink any alcoholic beverages?
  Answers: Daily; 4 – 5 times a week; 2 – 3 times a week; Once a week 2 – 3 times a month; Once; Don't remember\ Refusal (Spontaneous)
- QC3: On a day when you drink alcoholic beverages, how much do you usually drink?
  Answers: 1-2 drinks; 3-4 drinks; 5-6 drinks; 7-9 drinks; 10 drinks or more; It depends (Spontaneous); DK\ Refusal

These questions were combined to calculate the average daily amounts consumed in grammes. The mid-points of the answer categories from QC3 were multiplied with the assumed average 12 grammes of alcohol per drink: 1.5*12 g; 3.5*12g; 5.5*12g;

8*12g; 10*12g. These results were then multiplied with the frequencies from QC2 to obtain total weekly and average daily intake. Persons answering yes to either QC1a or QC1c, but having a NA on questions QC2 and/or QC3 were categorized as drinking rarely, that is, 0-0.025 g daily.

Following, four alcohol consumption categories were distinguished, using the cut-off points of the WHO (see table below). The two highest WHO categories were combined into a single highest category. Also the categories lifetime abstainer and former drinker were combined, and people indicating very small annual intake were added to this category of “not to rare drinkers”.

Men	0-0.025	0.025-40	40-60	60+
Women		0.025-20	20-40	40+

This resulted in three datasets with individual data containing information on country, age and gender, as well as lifestyle category (either overweight 3 categories, smoking habit 3 categories, or drinking habit 4 categories).

9.5 Overview of cost-effectiveness studies on lifestyle interventions in a European setting

Table 1: Alcohol

Study	Country	Outcome
1. Angus C, Scafato E, Ghirini S, Torbica A, Ferre F, Struzzo P, Purshouse R, Brennan A. Cost-effectiveness of a programme of screening and brief interventions for alcohol in primary care in Italy. BMC Fam Pract2014; 15(1): 26	Italy	QALY
2. Barrett B, Byford S, Crawford MJ, Patton R, Drummond C, Henry JA, Touquet R. Cost-effectiveness of screening and referral to an alcohol health worker in alcohol misusing patients attending an accident and emergency department: a decision-making approach. Drug Alcohol Depend2006; 81(1): 47-54	England	Level of drinking
3. Berg M van den, Baal PH van, Tariq L, Schuit AJ, Wit GA de, Hoogeveen RT. The cost-effectiveness of increasing alcohol taxes: a modelling study. BMC Med2008; 6(1): 36.	Netherlands	QALY
4. Blankers M, Nabitz U, Smit F, Koeter MWJ, Schippers GM. Economic evaluation of internet-based interventions for harmful alcohol use alongside a pragmatic randomized controlled trial. Journal of Medical Internet Research2012; 14(5)	Netherlands	QALY
5. Coulton S, Drummond C, James D, Godfrey C, Bland JM, Parrott S, Peters T. Opportunistic screening for alcohol use disorders in primary care: comparative study. Bmj2006; 332(7540): 511-7	England	Costs per true positive
6. Drummond C, Coulton S, James D, Godfrey C, Parrott S, Baxter J, Ford D, Lervy B, Rollnick S, Russell I, Peters T. Effectiveness and cost-effectiveness of a stepped care intervention for alcohol use disorders in primary care: pilot study. Br J Psychiatry2009; 195(5): 448-56	England	Alcohol consumption
7. Holm AL, Veerman L, Cobiac L, Ekholm O, Diderichsen F. Cost-effectiveness of changes in alcohol taxation in Denmark: a modelling study. Cost Eff Resour Alloc2014a; 12(1): 1	Denmark	DALY
8. Holm AL, Veerman L, Cobiac L, Ekholm O, Diderichsen F. Cost-effectiveness of preventive interventions to reduce alcohol consumption in denmark. PLoS One2014b; 9(2): e88041	Denmark	DALY
9. Kaner E, Lock C, Heather N, McNamee P, Bond S. Promoting brief alcohol intervention by nurses in primary care: a cluster randomised controlled trial. Patient Educ Couns2003; 51(3): 277-84	England	Correctly treated patient
10. Lai T, Habicht J, Reinap M, Chisholm D, Baltussen R. Costs, health effects and cost-effectiveness of alcohol and tobacco control strategies in Estonia. Health Policy2007.	Estonia	DALY
11. Long CG, Williams M, Hollin CR. Treating alcohol problems: a study of programme effectiveness and cost effectiveness according to length and delivery of treatment. Addiction1998; 93(4): 561-71	England	Days without use, drinking intensity
12. Mansdotter AM, Rydberg MK, Wallin E, Lindholm LA, Andreasson S. A cost-effectiveness analysis of alcohol prevention targeting licensed premises. Eur J Public Health2007.	Sweden	QALY
13. Palmer AJ, Neeser K, Weiss C, Brandt A, Comte S, Fox M. The long-term cost-effectiveness of improving alcohol abstinence with adjuvant acamprosate. Alcohol and Alcoholism, 2000;35:478-92.	Germany	Abstainers
14. Parrott S, Godfrey C, Heather N, Clark J, Ryan T. Cost and outcome analysis of two detoxification services. Alcohol and Alcoholism, 2006;41:84-91.	England	Unit reduction alcohol consumption
15. Purshouse RC, Brennan A, Rafia R, Latimer NR, Archer RJ, Angus CR, Preston LR, Meier PS. Modelling the Cost-Effectiveness of Alcohol Screening and Brief Interventions in Primary Care in England. Alcohol Alcohol2012.	England	QALY
16. Purshouse RC, Meier PS, Brennan A, Taylor KB, Rafia R. Estimated effect of alcohol pricing policies on health and health economic outcomes in England: an epidemiological model. Lancet2010.	England	Various
17. Smit F, Lokkerbol J, Riper H, Majo MC, Boon B, Blankers M. Modeling the Cost-Effectiveness of Health Care Systems for Alcohol Use Disorders: How Implementation of eHealth Interventions Improves Cost-Effectiveness. J Med Internet Res2011; 13(3): e56	Netherlands	DALY
18. Tariq L, van den Berg M, Hoogenveen RT, van Baal PH. Cost-effectiveness of an opportunistic screening programme and brief intervention for excessive alcohol use in primary care. PLoS One2009a; 4(5): e5696	Netherlands	QALY

19. UKATT. Cost effectiveness of treatment for alcohol problems: findings of the randomised UK alcohol treatment trial (UKATT). Bmj2005; 331(7516): 544	England	QALY, criminality, drinks per day
20.Watson J, Crosby H, Dale V, Tober G, Wu Q, Lang J, McGovern R, Newbury-Birch D, Parrott S, Bland J, Drummond C, Godfrey C, Kaner E, Coulton S. AESOPS: a randomised controlled trial of the clinical effectiveness and cost-effectiveness of opportunistic screening and stepped care interventions for older hazardous alcohol users in primary care. Health Technol Assess2013; 17(25): 1-158	England	QALY, alcohol related problems

Table 2: Overweight and Obesitas

Study	Country	Outcome
1. Ara R, Brennan A. The cost-effectiveness of sibutramine in non-diabetic obese patients: evidence from four Western countries. Obes Rev2007; 8(4): 363-71	4 countries	diabetes
2. Bemelmans W, van Baal P, Wendel-Vos W, Schuit J, Feskens E, Ament A, Hoogenveen R. The costs, effects and cost-effectiveness of counteracting overweight on a population level. A scientific base for policy targets for the Dutch national plan for action. Prev Med2008b; 46(2): 127-32	Netherlands	QALY
3. Brennan A, Ara R, Sterz R, Matiba B, Bergemann R. Assessment of clinical and economic benefits of weight management with sibutramine in general practice in Germany. Eur J Health Econ2006; 7(4): 276-84	Germany	QALY
4. Foxcroft DR. Orlistat for the treatment of obesity: cost utility model. Obes Rev2005; 6(4): 323-8	England	QALY
5. Fuller NR, Colagiuri S, Schofield D, Olson AD, Shrestha R, Holzapfel C, Wolfenstetter SB, Holle R, Ahern AL, Hauner H, Jebb SA, Caterson ID. A within-trial cost-effectiveness analysis of primary care referral to a commercial provider for weight loss treatment, relative to standard care--an international randomised controlled trial. Int J Obes (Lond)2013b; 37(6): 828-34	Australia, England, Germany	QALY
6. Galani C, Schneider H, Rutten FF. Modelling the lifetime costs and health effects of lifestyle intervention in the prevention and treatment of obesity in Switzerland. Int J Public Health2007b; 52(6): 372-82	Switzerland	QALY
7. Gusi N, Reyes MC, Gonzalez-Guerrero JL, Herrera E, Garcia JM. Cost-utility of a walking programme for moderately depressed, obese, or overweight elderly women in primary care: a randomised controlled trial. BMC Public Health2008; 8: 231	Spain	QALY
8. Hertzman P. The cost effectiveness of orlistat in a 1-year weight-management programme for treating overweight and obese patients in Sweden: a treatment responder approach. Pharmacoeconomics2005; 23(10): 1007-20	Sweden	QALY
9. Hollinghurst S, Hunt LP, Banks J, Sharp DJ, Shield JP. Cost and effectiveness of treatment options for childhood obesity. Pediatr Obes2013.	England	BMI
10. Hollingworth W, Hawkins J, Lawlor DA, Brown M, Marsh T, Kipping RR. Economic evaluation of lifestyle interventions to treat overweight or obesity in children. Int J Obes (Lond)2012.	UK	Life years gained
11. Iannazzo S, Zaniolo O, Pradelli L. Economic evaluation of treatment with orlistat in Italian obese patients. Curr Med Res Opin2008; 24(1): 63-74	Italy	QALY
12. Kalavainen M, Karjalainen S, Martikainen J, Korppi M, Linnosmaa I, Nuutinen O. Cost-effectiveness of routine and group programs for treatment of obese children. Pediatr Int2009.	Finland	BMI
13. Kesztyus D, Schreiber A, Wirt T, Wiedom M, Dreyhaupt J, Brandstetter S, Koch B, Wartha O, Muche R, Wabitsch M, Kilian R, Steinacker JM. Economic evaluation of URMEL-ICE, a school-based overweight prevention programme comprising metabolism, exercise and lifestyle intervention in children. Eur J Health Econ2011.	Germany	Waist circumference
14. Lacey LA, Wolf A, O'Shea D, Erny S, Ruof J. Cost-effectiveness of orlistat for the treatment of overweight and obese patients in Ireland. Int J Obes (Lond)2005; 29(8): 975-82	Ireland	QALY

15. McConnon A, Kirk SF, Cockroft JE, Harvey EL, Greenwood DC, Thomas JD, Ransley JK, Bojke L. The Internet for weight control in an obese sample: results of a randomised controlled trial. BMC Health Serv Res2007; 7: 206	England	QALY
16. Miners A, Harris J, Felix L, Murray E, Michie S, Edwards P. An economic evaluation of adaptive e-learning devices to promote weight loss via dietary change for people with obesity. BMC Health Serv Res2012; 12(1): 190	England	QALY
17. Olsen J, Willaing I, Ladelund S, Jorgensen T, Gundgaard J, Sorensen J. Cost-effectiveness of nutritional counseling for obese patients and patients at risk of ischemic heart disease. International Journal of Technology Assessment in Health Care, 2005;21:194-202	Denmark	Life years gained
18. Siggaard R, Raben A, Astrup A. Weight loss during 12 week's ad libitum carbohydrate-rich diet in overweight and normal-weight subjects at a Danish work site. Obes Res1996; 4(4): 347-56	Denmark	Weight
19. Trueman P, Haynes SM, Felicity Lyons G, Louise McCombie E, McQuigg MS, Mongia S, Noble PA, Quinn MF, Ross HM, Thompson F, Broom JI, Laws RA, Reckless JP, Kumar S, Lean ME, Frost GS, Finer N, Haslam DW, Morrison D, Sloan B. Long-term cost-effectiveness of weight management in primary care. Int J Clin Pract2010.	England	Weight
20. van Baal PH, van den Berg M, Hoogenveen RT, Vijgen SM, Engelfriet PM. Cost-Effectiveness of a Low-Calorie Diet and Orlistat for Obese Persons: Modeling Long-Term Health Gains through Prevention of Obesity-Related Chronic Diseases. Value Health2008a.	Netherlands	QALY
21. Warren E, Brennan A, Akehurst R. Cost-effectiveness of sibutramine in the treatment of obesity. Med Decis Making2004; 24(1): 9-19	England	QALY

Table 3: Smoking

Study	**Country**	**Outcome**
1. Annemans L, Nackaerts K, Bartsch P, Prignot J, Marbaix S. Cost effectiveness of varenicline in Belgium, compared with bupropion, nicotine replacement therapy, brief counselling and unaided smoking cessation: a BENESCO Markov cost-effectiveness analysis. Clin Drug Investig2009b; 29(10): 655-65	Belgium	QALY
2. Athanasakis K, Igoumenidis M, Karampli E, Vitsou E, Sykara G, Kyriopoulos J. Cost-Effectiveness of Varenicline Versus Bupropion, Nicotine-Replacement Therapy, and Unaided Cessation in Greece. Clinical Therapeutics2012b; 34(8): 1803-1814	Greece	Quitter
3. Bauld L, Boyd KA, Briggs AH, Chesterman J, Ferguson J, Judge K, Hiscock R. One-Year Outcomes and a Cost-Effectiveness Analysis for Smokers Accessing Group-Based and Pharmacy-Led Cessation Services. Nicotine Tob Res201113 (2): 135-45	England	QALY
4. Bolin K, Lindgren B, Willers S. The cost utility of bupropion in smoking cessation health programs: simulation model results for Sweden. Chest2006; 129(3): 651-60	Sweden	QALY
5. Bolin K, Mork AC, Willers S, Lindgren B. Varenicline as compared to bupropion in smoking-cessation therapy--cost-utility results for Sweden 2003. Respir Med2008; 102(5): 699-710	Sweden	QALY
6. Bolin K, Mork AC, Wilson K. Smoking-cessation therapy using varenicline: the cost-utility of an additional 12-week course of varenicline for the maintenance of smoking abstinence. J Eval Clin Pract2009a; 15(3): 478-85	Sweden	QALY
7. Bolin K, Wilson K, Benhaddi H, de Nigris E, Marbaix S, Mork AC, Aubin HJ. Cost-effectiveness of varenicline compared with nicotine patches for smoking cessation--results from four European countries. Eur J Public Health2009b; 19(6): 650-4	BE, FRA, SW and England	QALY
8. Boyd KA, Briggs AH. Cost-effectiveness of pharmacy and group behavioural support smoking cessation services in Glasgow. Addiction2009; 104(2): 317-325.	Schotland	QALY
9. Brown J, Kotz D, Michie S, Stapleton J, Walmsley M, West R. How effective and cost-effective was the national mass media smoking cessation campaign 'Stoptober'?. Drug Alcohol Depend20141; 135: 52-8	England	Life years
10. Chevreul K, Cadier B, Durand-Zaleski I, Chan E, Thomas D. Cost effectiveness of full coverage of the medical management of smoking	France	Life years

cessation in France. Tob Control2012.		
11. Coleman T, Agboola S, Leonardi-Bee J, Taylor M, McEwen A, McNeill A. Relapse prevention in UK Stop Smoking Services: current practice, systematic reviews of effectiveness and cost-effectiveness analysis. Health Technology Assessment, 2010;14:1-152.	England	QALY
12. Cornuz J, Gilbert A, Pinget C, McDonald P, Slama K, Salto E, Paccaud F. Cost-effectiveness of pharmacotherapies for nicotine dependence in primary care settings: a multinational comparison. Tob Control2006; 15(3): 152-9	6 countries	Life years
13. Cornuz J, Pinget C, Gilbert A, Paccaud F. Cost-effectiveness analysis of the first-line therapies for nicotine dependence. Eur J Clin Pharmacol2003; 59(3): 201-6	Switserland	Life years
14. Feenstra TL, Hamberg-van Reenen HH, Hoogenveen RT, Rutten-van Molken MP. Cost-effectiveness of face-to-face smoking cessation interventions: a dynamic modeling study. Value Health2005b; 8(3): 178-90	Netherlands	QALY
15. Godfrey C, Parrott S, Coleman S, Pound E. The cost-effectiveness of the English smoking treatment services: evidence from practice. Addiction, 2005;100:70-83.	England	Life years
16. Guerriero C, Cairns J, Roberts I, Rodgers A, Whittaker R, Free C. The cost-effectiveness of smoking cessation support delivered by mobile phone text messaging: Txt2stop. Eur J Health Econ2012.	England	QALY
17. Hind D, Tappenden P, Peters J, Kenjegalieva K. Varenicline in the management of smoking cessation: a single technology appraisal, Healt Technol Assess 2009; 13 Suppl 2: 9-13.	England	QALY
18. Hoeflmayr D, Hanewinkel R. Do school-based tobacco prevention programmes pay off? The cost-effectiveness of the 'Smoke-free Class Competition'. Public Health2008122(1): 34-41	Germany	Smokers avoided
19. Hojgaard B, Olsen KR, Pisinger C, Tonnesen H, Gyrd-Hansen D. The potential of smoking cessation programmes and a smoking ban in public places: comparing gain in life expectancy and cost effectiveness. Scand J Public Health2011.	Denmark	Life years
20. Hollingworth W, Cohen D, Hawkins J, Hughes RA, Moore LA, Holliday JC, Audrey S, Starkey F, Campbell R. Reducing Smoking in Adolescents: Cost-Effectiveness Results From the Cluster Randomized ASSIST (A Stop Smoking In Schools Trial). Nicotine Tob Res201114(2): 161-8	England	non smoker for 2 years
21. Hoogendoorn M, Welsing P, Molken MP. Cost-effectiveness of varenicline compared with bupropion, NRT, and nortriptyline for smoking cessation in the Netherlands. Curr Med Res Opin200824(1): 51-61	Netherlands	QALY and quitter
22. Johansson PM, Tillgren PE, Guldbrandsson KA, Lindholm LA. A model for cost-effectiveness analyses of smoking cessation interventions applied to a Quit-and-Win contest for mothers of small children. Scand J Public Health2005; 33(5): 343-52	Sweden	QALY and quitter
23. Kaper J, Wagena EJ, van Schayck CP, Severens JL. Encouraging smokers to quit: the cost effectiveness of reimbursing the costs of smoking cessation treatment. Pharmacoeconomics2006a; 24(5): 453-64	Netherlands	QALY and quitter
24. Knight C, Howard P, Baker CL, Marton JP. The Cost-Effectiveness of an Extended Course (12 + 12 Weeks) of Varenicline Compared with Other Available Smoking Cessation Strategies in the United States: An Extension and Update to the BENESCO Model. Value Health201013(2): 209-14	England	QALY and quitter
25. Knight C, Marbaix S, Annemans L, Prignot J, Bowrin K. The cost-effectiveness of an extended course (12+12 weeks) of varenicline plus brief counselling compared with other reimbursed smoking cessation interventions in Belgium, from a Public Payer perspective. Acta Clin Belg2012; 67(6): 416-22	Belgium	QALY
26. Kotz D, Stapleton JA, Owen L, West R. How cost-effective is 'No Smoking Day'?. Tob Control2010.	England	Life years
27. Linden K, Jormanainen V, Linna M, Sintonen H, Wilson K, Kotomaki T. Cost effectiveness of varenicline versus bupropion and unaided cessation for smoking cessation in a cohort of Finnish adult smokers. Curr Med Res Opin2010; 26(3): 549-60	Finland	QALY
28. Mudde AN, Vries H de, Strecher VJ. Cost-effectiveness of smoking cessation modalities: comparing apples with oranges? Prev Med1996; 25: 708-716.	Netherlands	Quitter

29. Nohlert E, Helgason AR, Tillgren P, Tegelberg A, Johansson P. Comparison of the Cost-Effectiveness of a High- and a Low-Intensity Smoking Cessation Intervention in Sweden: A Randomized Trial. Nicotine Tob Res2013.	Sweden	QALY
30. Olsen KR, Bilde L, Juhl HH, Kjaer NT, Mosbech H, Evald T, Rasmussen M, Hiladakis H. Cost-effectiveness of the Danish smoking cessation interventions: Subgroup analysis based on the Danish Smoking Cessation Database. Eur J Health Econ2006.	Denmark	Life years
31. Over EA, Feenstra TL, Hoogenveen RT, Droomers M, Uiters E, van Gelder BM. Tobacco Control Policies Specified According to Socioeconomic Status: Health Disparities and Cost-effectiveness. Nicotine Tob Res2014.	Netherlands	QALY
32. Pieroni L, Chiavarini M, Minelli L, Salmasi L. The role of anti-smoking legislation on cigarette and alcohol consumption habits in Italy. Health Policy2013; 111(2): 116-26	Italy	QALY
33. Pinget C, Martin E, Wasserfallen JB, Humair JP, Cornuz J. Cost-effectiveness analysis of a European primary-care physician training in smoking cessation counseling. Eur J Cardiovasc Prev Rehabil2007; 14(3): 451-455	Switzerland	Life years
34. Ranson MK, Jha P, Chaloupka FJ, Nguyen SN. Global and regional estimates of the effectiveness and cost-effectiveness of price increases and other tobacco control policies. Nicotine Tob Res2002; 4(3): 311-9	England	DALY
35. Rasmussen SR. The cost effectiveness of telephone counselling to aid smoking cessation in Denmark: A modelling study. Scand J Public Health2012.	Denmark	Life years
36. Ratcliffe J, Cairns J, Platt S. Cost effectiveness of a mass media-led anti-smoking campaign in Scotland. Tob Control1997; 6(2): 104-10	Scotland	Life years
37. Salize HJ, Merkel S, Reinhard I, Twardella D, Mann K, Brenner H. Cost-effective primary care-based strategies to improve smoking cessation: more value for money. Arch Intern Med2009; 169(3): 230-5; discussion 235-6	Germany	quitter
38. Smit ES, Evers SM, de Vries H, Hoving C. Cost-effectiveness and cost-utility of internet-based computer tailoring for smoking cessation. J Med Internet Res2013; 15(3): e57	Netherlands	quitter
39. Song F, Raftery J, Aveyard P, Hyde C, Barton P, Woolacott N. Cost-effectiveness of pharmacological interventions for smoking cessation: a literature review and a decision analytic analysis. Med Decis Making2002; 22(5 Suppl): S26-37	England	Life years
40. Stapleton JA, Lowin A, Russell MA. Prescription of transdermal nicotine patches for smoking cessation in general practice: evaluation of cost-effectiveness. Lancet1999; 354(9174): 210-5	England	Life years
41. Stevens W, Thorogood M, Kayikki S. Cost-effectiveness of a community anti-smoking campaign targeted at a high risk group in London. Health Promot Int2002c; 17(1): 43-50	England	Life years
42. Taylor M, Leonardi-Bee J, Agboola S, McNeill A, Coleman T. Cost Effectiveness of Interventions to Reduce Relapse to Smoking Following Smoking Cessation. Addiction2011.	England	QALY
43. Tomson T, Helgason AR, Gilljam H. Quitline in smoking cessation: a cost-effectiveness analysis. Int J Technol Assess Health Care2004; 20(4): 469-74	Sweden	Life years
44. Van Baal PH, Brouwer WB, Hoogenveen RT, Feenstra TL. Increasing tobacco taxes: a cheap tool to increase public health. Health Policy2007; 82(2): 142-52	Netherlands	QALY
45. Vemer P, Rutten-van Molken MP, Kaper J, Hoogenveen RT, van Schayck CP, Feenstra TL. If you try to stop smoking, should we pay for it? The cost-utility of reimbursing smoking cessation support in the Netherlands. Addiction2010; 105(6): 1088-97	Netherlands	QALY
46. Vijgen SM, van Baal PH, Hoogenveen RT, de Wit GA, Feenstra TL. Cost-effectiveness analyses of health promotion programs: a case study of smoking prevention and cessation among Dutch students. Health Education Research2008; 23(2): 310-8	Netherlands	QALY
47. Wang D, Connock M, Barton P, Fry-Smith A, Aveyard P, Moore D. 'Cut down to quit' with nicotine replacement therapies in smoking cessation: a systematic review of effectiveness and economic analysis. Health Technol Assess2008a; 12(2): 1-156	England	QALY
48. Wu Q, Parrott S, Godfrey C, Gilbert H, Nazareth I, Leurent B, Sutton S, Morris R. Cost-Effectiveness of Computer-Tailored Smoking Cessation Advice in Primary Care: A Randomized Trial (ESCAPE). Nicotine Tob Res2013d.	England	QALY

9.6 Validation phases: Study design and expert workshop.

Study design, form and summary of results.

Study Design for review purposes

"Life Table Analysis: health system cost-effectiveness assessments across Europe"

Tender n° EAHC/2013/Health/05

Contract notice 2013/S 043143 of 27/03/2013

by
National Institute for Public Health and the Environment (RIVM), in cooperation with ErasmusMC and Erasmus University.

Bilthoven, The Netherlands, January, 2014.

Contents

1. Questions for reviewers

This document describes our study design. While aiming to keep it readable and short, we have added some tables and appendices with additional detail. Of course, if you have any further questions, you could contact us: Talitha.Feenstra@rivm.nl, or Richard.Heijink@rivm.nl.

Our question to you as a reviewer is to comment on the study design, focusing on those parts that concern your expertise. To enable finding these parts, we have made ample use of subheadings throughout the text. That is, we do not expect you to comment on the entire text, although you may of course feel free to do so.
The text starts with our main objective. Then in sections 3, 5, 6 and 7 our approach is described, while section 4 gives the data sources and definitions we plan to use. Finally section 8 shortly overviews the timelines of the project. The appendices give an overview of the organization of the project, a list of country abbreviations, data sources considered for lifestyle factors and a reference list.

Please give us your reaction to the following questions:

1. Do you agree with the approach (data sources/output measures) proposed?
2. What could be advantages of the current approach?
3. What could be important limitations?
4. What are caveats to be aware of? E.g. risks of bias to take into account.
5. Do you have suggestions regarding references or experts to consult?
6. Did we miss important data sources?

It is important to keep in mind that the current research project will have a limited budget and time horizon of 12 months. Nevertheless, the results have to be sufficiently reliable and enable sound interpretation.

For your reaction you may apply the form attached, or just use your own preferred format. Please indicate your area(s) of expertise, your answer to the 6 questions above and any further comments you wish to make.

2. Main Objective

The main objective of this project is to assess the comparative cost-effectiveness of 31 European health systems, while correcting for the impact of three lifestyle factors (tobacco, alcohol, and overweight) on both health spending and outcomes.

Life-table analyses will link lifestyle to outcomes. Subsequently, regression analysis on standardized estimates of total spending and health outcomes will produce lifestyle adjusted cost-effectiveness frontiers. Based on these, further quantitative and qualitative analysis of the relative performance of health systems across Europe will be done.

The countries involved are the EU28 plus Norway, Iceland and Liechtenstein (see appendix for a full list), as commissioned by the Executive Agency for Health and Consumers (EAHC). Missing data will be approximated, consulting country–experts for validity.

3. Health system cost-effectiveness analysis

3.1 Visualizing cost-effectiveness

The analysis will start with simple scatter plots of the relationship between health spending and health, plotting country-level health spending on the x-axis and country-level health outcomes on the y-axis. Information on definitions is given below and in section 4 on data sources used.

3.1.1 Health expenditures

Previous studies often used total health expenditure, as defined in the System of Health Accounts (SHA) (e.g. Nixon and Ulmann, 2006; Joumard et al., 2010; Heijink et al., 2013). We will use this as a starting point. Besides, we will apply a more strict definition of health expenditures, only including SHA-categories that are expected to have an impact on the health outcomes measured. Using the provider dimension, we will include hospitals, ambulatory care and providers of medical goods (table 1). Using the functional dimension, we will include curative and rehabilitative care, ancillary services to health care and medical goods (table 1).

3.1.2 Health outcomes

As a measure of health benefits, we will use three measures that are all official European Community Health Indicators (ECHI), chosen by the ECHI Monitoring (ECHIM) project (Tuomi-Nikula et al. 2012): Life Expectancy (LE), Healthy Life Years (HLY) i.e. Life expectancy without disability, and Life expectancy in good perceived health (LEGHP).

3.2 Uncorrected cost-effectiveness curves.

Regression analyses (using health outcomes as dependent variable and health expenditure as independent variable) on country level data will estimate health system efficiency of individual countries. We will apply corrected ordinary least squares (c-OLS), that is all unexplained variation in health outcomes between countries will be attributed to inefficiency. For comparison, also other interpretations of the unexplained variation will be analyzed (for an overview of approaches, see Hollingsworth, 2003; Jacobs et al., 2006).

3.3 Cost-effectiveness graphs and curves corrected for lifestyle.

The main objective of the current project is to adjust health system cost-effectiveness for the impact of lifestyle factors. Therefore, both health spending and health outcomes will be standardized using the methods proposed in section 4. Following, adjusted scatter plots will be produced, using the lifestyle standardized outcomes. Moreover, these standardized outcomes will be used to re-estimate the regression models and health system efficiency of individual countries.

An important difference to other approaches (as in e.g. Nixon and Ulmann, 2006; Joumard et al., 2010; Heijink et al., 2013) is that we standardize both spending and health outcomes for lifestyle, rather than including lifestyle as a covariate in the regression model. This enables to produce easy to interpret graphical representations.

3.4 Further analyses: covariates and time lags.

In a third step, additional covariates will be added, using those that came out as significant in other studies, namely educational level, per capita gross domestic product (GDP), and health system typology.

Finally, attention will be paid to possible time lags between health spending and its effects on health outcomes. These analyses will concentrate on a subset of countries, for which we have panel data on both health spending, health outcomes and macro-level lifestyle indicators. Lifestyle corrections in these time series will necessarily be more straightforward than the elaborate corrections in the main analyses.

4. Data selection for quantitative analysis

The data sources for information on health spending, health outcomes, lifestyle factors, and demographic data are given below. Our choice was guided by three principles. First, we aimed to be consistent with the recommendations of the ECHIM-Joint Action final report (Tuomi-Nikula et al. 2012). Second, we aimed for data that were comparable across countries, hence preferably from large multi country surveys, or from sources that had paid attention to comparability. Third, we needed data specific to age and gender. Liechtenstein (37,000 inhabitants) is unavailable in most databases. We will approach by using neighboring countries and national statistics. Our data will refer to adults aged 15 years and over. For lifestyle variables, the appendix provides an overview of data sources evaluated and their status in the study design (primary source, additional source, or not used).

4.1 Data on health expenditure.

The World Health Organization (WHO), Organisation for Economic Co-operation and Development (OECD) and Eurostat jointly collect data on health spending from national agencies according to the System of Health Accounts (SHA) framework. The framework distinguishes three dimensions (see table 1).

Financing	Provider	Function
General government (general and social security funds)	Hospitals	Curative and rehabilitative care
Private sector (private insurance, out-of-pocket, other)	Nursing and residential care facilities	Long-term nursing care
Rest of the world	Ambulatory care	Ancillary services to health care (laboratory, diagnostic imaging, patient transport)
	Providers of medical goods	Medical goods (pharmaceuticals and appliances)
	Public health programs	Prevention and public health services
	General health administration and insurance	Health administration and health insurance
	Other industries	Not specified by kind
	Rest of the world	
		Total current health expenditure
		Capital formation
Total health expenditure	**Total health expenditure**	**Total health expenditure**

Table 4.1: Different dimensions in the SHA.

4.2 Data on health outcomes.

The Eurostat database[2] and Eurohex[3] databases contain data on self-reported health and disability (Global Activity Limitation Indicator, GALI). These indicators will be used to calculate Healthy Life Years (HLY) and Life expectancy in good perceived health (LEGHP) in addition to life expectancy. These life and health expectancies are published on an annual basis for all EU member states, Norway, and Iceland.

4.3 Data on Lifestyle Factors.

4.3.1 Smoking

For smoking, we propose as our main data source the Eurobarometer, a multi-country survey in the entire EU with its most recent round in 2012. (TNS NIPO 2012, [12]) This recent survey contains the % of regular daily smokers (ECHI 44), as well as the % of former smokers. For countries with missing information, a mapping is to be developed that links %s of smokers to Eurostat data on total sales of cigarettes. For additional sources see appendix. The choice is conditional on getting access to Eurobarometer data.

4.3.2 Alcohol

For alcohol, the ECHI indicators are: total adult (age 15+) per capita consumption (liters of pure alcohol, ECHI 46) and hazardous use (ECHI 47). WHO and EU cooperate to provide information through EUSAH (part of GISAH) [10]. Liters per capita are available for recent years (2010-2012) for 30 countries, through the EU HEIDI tool

[13]. Preferably, we will add information on average consumption level per country, according to the EMA/WHO categorization (table 2). This categorization is very detailed enabling to combine categories when necessary for data availability or modeling, since surveys vary in their categorizations. Rehm et al. (2012) present a method to use country-specific data on total consumption (liters per capita) along with global information on distributions to calculate country specific divisions into categories of consumption level. They present this information for 2009 for 30 countries (not LT). The most recent Eurobarometer survey on alcohol was performed in 2009, covers the EU27 and categorizes in terms of drinks per day.(TNS NIPO 2010) We will compare these data and the approach from Rehm et al. to find age and gender specific distributions over categories of alcohol consumption.

Men	Lifetime abstainer	Former drinker	0-40	40-60	60-100	100+
Women			0-20	20-40	40-60	60+

Table 4.2: WHO/EMA categorization of alcohol consumption in grams of alcohol (on average)

4.3.3 **Overweight**

The ECHI includes BMI as indicator of overweight (ECHI 42). It distinguishes normal weight, overweight or moderate obesity (defined as a BMI between 25 and 29.9), and severe obesity (defined as a BMI of 30 and over). For the prevalence of obesity, WHO data will be used with reference year 2008.[14] In addition, a recent IASO(international Association for the study of Obesity) publication on overweight and obesity in the EU27 contains results from national surveys with varying reference years ranging from 2003 to 2012 [11].

4.4 Demographic data.

The Eurostat data are highly standardized in order to secure international comparability. We use the Eurohex database [3] for population data and death counts for all EU27 countries, Croatia, Norway, and Iceland. For Liechtenstein national data will be used.

4.5 Data linking lifestyle to health outcomes.

Odds ratios linking risk factor exposure to health outcomes (GALI and self-perceived health) will be obtained from the SHARE (Survey of Health and Retirement in Europe, [8]). Odds ratios will be assumed constant over all countries and regions. These ratios will link current lifestyle to current health outcomes. For smoking, ratios for former smokers will also be estimated. For alcohol and overweight, the main health effects are linked to current behavior. For alcohol, the main exception to this rule is cancer, with total lifetime exposure being the main explanatory factor. However, "on an epidemiological level, most of the burden may be related to current drinking." (Rehm et al. 2012) ECHIM also proposes current alcohol use to calculate attributable mortality, while including current and former smokers.(Tuomi-Nikula et al. 2012) Relative risks of lifestyle for all-cause mortality will be taken from literature.

5. Standardizing health and health spending for lifestyle

We will apply the existing DYNAMO-HIA (DYNamic MOdeling for Health Impact Assessment) Model to calculate lifestyle standardized outcomes.(Boshuizen et al. 2012) The 31 countries and many scenarios involved make it more practical and less error prone to use this dedicated software. DYNAMO-HIA includes checks of the input data (e.g. total prevalence of risk factor equals 100%) and has data storage capacities.

We will run DYNAMO-HIA with lifestyle risk factors directly linked to general health outcomes. This avoids the use of less comparable and often unavailable country specific disease prevalence, incidence and mortality data, as well as disease and country specific cost data that will be impossible to obtain for all 31 countries included.

5.1 Model extension.

The output of DYNAMO-HIA will be mortality probabilities, prevalence of self-rated health/disability by age, gender and country and life and health expectancy (HLY, LEGHP) in various scenarios in which risk factor levels are varied.

In order to also calculate health spending in these various scenarios we will need estimates of health spending stratified by age, gender, country/region and preferably also self-rated health/disability, mortality risk and/or risk factor level. We will estimate the relation between age, risk factors, mortality risk, self-rated health/disability and health spending. We will try several model specifications based on the scientific literature. The results will be validated using literature on the topic and our own earlier work for the Netherlands. Preferably, these estimates are to be performed at least region (Nordic, North-West, East and South Europe) specific, since differences in unit costs will affect the relations found. The resulting regression models explaining health spending will be used to correct aggregate country level health spending as described in the previous section for lifestyle changes assumed in the different scenarios (section 5.2 below).

The current version of DYNAMO-HIA allows to model one risk factor per scenario. An important extension that will be made to the model as part of the proposed project is to allow for multiple risk factors so that in scenario analyses all three risk factors can be changed simultaneously and a non-smoking, normal weight, normal drinking population can be compared to e.g. a smoking, normal weight, normal drinking population (benchmarking).

5.2 Scenario analysis-standardization.

The below scenarios were included in the tender call for the standardization of lifestyle factor prevalence across countries (that is, 31 countries, and the EU-27 as a whole):

A. All prevalences of unhealthy behavior set to 0%,
B. All prevalences set – stepwise by 10% increases - to 100% for each lifestyle factor
C. All prevalences set to observed (cross-country) minimal prevalences
D. All prevalences set to observed (cross-country) maximal prevalences

E. All prevalences set to those of the country that presents the median observation across countries in terms of health outcome
F. All prevalences set to those of the country that presents the median observation across countries in terms of health expenditure.

All 5 separate scenarios (A and C to F) will be calculated. We will use multifactorial design combined with meta-modelling/interpolation to calculate the results for the stepwise increases in scenarios B.

5.3 Time lags

Since we use the model to standardize both health outcomes and health care spending, we apply current lifestyle factors to standardize current results. Of course, current outcomes and current spending are affected also by previous lifestyle. For smoking, former smokers are explicitly included to reflect the strong risks they still run compared to never smokers. However, delays in the effects of lifestyle on health outcomes are different for each disease and lifestyle factor, therefore fully including these relations would require very complex modeling. Our main approach involves standardizing both sides of the regression equation for current lifestyle in a similar way. By using age-specific data, further effects of time lags should be relatively small. Countries with different histories regarding lifestyle will show different age profiles in lifestyle and hence the results of standardization will be different.

5.4 Validation.

To test the robustness of the proposed approach that links risk factors directly to health outcomes, and to analyze the effects of time lags in more detail, we will work through the complete DYNAMO-HIA model with explicit modeling of diseases for The Netherlands and if possible also for Germany. These two countries have detailed cost data available. [1,5] Comparing both approaches for these countries provides further insight into the robustness of results.

6. Incremental cost effectiveness of changes in lifestyle

The comparison of the scenarios with the baseline (starting from the non-standardized "as is" situation) will be used to calculate incremental cost-effectiveness outcomes in terms of extra € spent or saved per added unit of health outcome (Life expectancy, HLY, Life expectancy in good perceived health). Since (the cost of) specific interventions are not included, these incremental cost effectiveness outcomes are not true cost-effectiveness ratios as usually applied.(E.G. Vos et al. 2010) They rather express how country-specific costs and health outcomes may change according to hypothetical lifestyle factor prevalence changes.
Note that this is something else than comparing different countries' position against the estimated (standardized) regression curves. The latter provides insight into the potential efficiency gains by moving further towards the curve, e.g. by system changes.

From our literature review, we will compose an overview of lifestyle interventions addressing the three lifestyle factors at stake (smoking, alcohol and overweight/obesity) and their cost-effectiveness. Combining information from literature with our own scenario analyses will then provide a first underpinning of the magnitude of health gains to be gained with additional investments in lifestyle interventions in the difference geographical entities.

7. Qualitative analysis for further interpretation of the results

In a qualitative analysis, we will take a broader view on the topic and analyze possible explanations and implications of the results, using the health system frameworks developed in the RIVM Public Health Forecasting.
The qualitative analysis includes discussing the role of other important lifestyle factors such as physical activity level. Health systems may generate benefits or outputs in addition to better average health, and not included in the cost-effectiveness ratio. Furthermore, the chapter will discuss the role of determinants of health such as social conditions and the general economic situation. The chapter will also pay attention to aspects related to health policy and tentatively come with recommendations. Our outcomes will be compared with results from studies on the cost-effectiveness of interventions aiming at lifestyle factors.
We will finally focus on the proportionality between investment in health promotion and disease prevention, and expenditure on disease treatment in the long term and differences between countries. This will be performed conditional on data availability and with due attention to consistency over countries.

8. Planning

After the current review round, the study design will be finalized. The quantitative analyses will start, and an interim report is due at the end of June 2014. During summer, the qualitative analyses will be performed. All study findings will be presented to external experts (not the current reviewers) in a workshop in autumn 2014. To enhance a lively discussion, a draft report will be sent to the experts involved ahead of this meeting, so that they can prepare themselves. The discussion then takes place based on discussion questions.

Appendix

Project members

RIVM: Dr GA de Wit, Dr TL Feenstra, Dr R Heijink, Dr M van den Berg, and Prof dr H Boshuizen.

iMTA, Erasmus University: Dr PHM van Baal, Dr C de Meijer.

University Medical Center Rotterdam: Dr W Nusselder, Drs. D Wapperom

Expert committee

Prof J Polder, Prof J Mackenbach, Dr A Wong, Dr W Bemelmans and Prof W Brouwer.

Table 3: time schedule of activities,

Time (month)	Activities
M2	Written study design for review by experts
M3-M6 [i]	Health system c/e
	Quantitative analyses using DYNAMO HIA and regression analyses.
M6	Interim report
M7-M9	Qualitative analysis and discussion
	Workshop with experts. M9
M10	Processing comments
M11-M12	Additional deliverables and finetuning of final study

Table 4: List of deliverables and tasks.

Deliverable (D)/Task (T)	Type of output
T1. Literature review	Contribution to study design and report
D1. Inception report	Report
T2. Study Design	Study Design
T3. Validity assessment of study design	Final study design in report
T4. Health System cost effectiveness	Contents of report, graphs and tables
D2. Interim Report	Report
T5. Discussion	Contents of report
T6. Qualitative analysis of implications	Contents of report
T7. Validity Assessment	Improvement of final study
D3. Final Study	Report
D4. Electronic data file	Data file
D5. Report on validation	Added to report
D6. Executive summary	Included in report
D7. Abstract	Included in report

List of countries and their abbreviations.

AT	AUSTRIA	
BE	BELGIUM	
BG	BULGARIA	
HR	CROATIA	
CY	CYPRUS	
CZ	CZECH	REPUBLIC
DK	DENMARK	
EE	ESTONIA	
FI	FINLAND	
FR	FRANCE	
DE	GERMANY	
EL	GREECE	
HU	HUNGARY	
IS	ICELAND	
IE	IRELAND	
IT	ITALY	
LV	LATVIA	
LI	LIECHTENSTEIN	
LT	LITHUANIA	
LU	LUXEMBOURG	
MT	MALTA	
NL	NETHERLANDS	
NO	NORWAY	
PL	POLAND	
PT	PORTUGAL	
RO	ROMANIA	
SK	SLOVAKIA	(Slovak
SI	Republic)	
ES	SLOVENIA	
SE	SPAIN	
UK	SWEDEN	
	UNITED KINGDOM	

EU27=all countries above except HR, IS,NO,LT. EU28=all countries except NO,IS, LT.

Impact of lifestyle on macro cost-effectiveness

Using regression models, the efficiency of individual countries can be estimated in different ways: attributing all remaining variation, besides what is explained by covariates, to inefficiency. This is called corrected ordinary least squares, and implies a shift of the OLS function to a frontier combining the most efficient countries; or attributing part of the deviation to inefficiency and part to random noise. This method is called stochastic frontier analysis.

Data sources for lifestyle factors

A EAHC requirement is that all data are at least from 2005 or onwards. This disqualifies a number of older surveys, among which the data from the Eurothines project, which were applied in a previous DYNAMO HIA application.

The following tables contain an overview of more recent data sources evaluated for each of the three lifestyle factors.

Table 5 Overview of datasources available for the different lifestyle variables needed. Tobacco

Source	Variable	Year (most recent)	Countries	Comments	
Eurostat [2]	% of current, former, never smokers	2009	EU27+NO		
EHIS [2]	% daily smokers	2006-2010	Limited[6]	2nd wave in 2014	By gender and age (8 cats)
Eurobarometer [12]	% current, former, never smokers	2012	EU27 (Misses HR, NO,ICE)	About 1000 respondents per country	By gender and age, but small numbers
WHO GHO [14]	Adult smoking, daily and current smoking %	Varies,	EU28, NO, ICE	National surveys.	Metadata and estimates for 2008 and 2010.
WHO Infobase	% daily smokers	OLD	Worldwide	Seems often older than 2005.	By age and gender
WHO HFA DB [9]	% daily smokers	2008-2011	EU, not PO	Based on national surveys	Only by age by reference to national surveys.
OECD Health data [7]	% daily smokers.	2009-2012	Limited	Incomplete regarding countries	Not by age? By gender

Further notes concerning smoking
Sources mainly found by direct consultation of online databases.

Comparability affected by cigarette smokers (or smokers in general), definition of current smoker (frequency and amount).

[6] The first wave of the EHIS was implemented during the period 2006-2009 under a gentlemen's agreement. Nineteen countries have carried it out in the following years. 2006: AT, EE; 2007: SI, CH; 2008: BE, BG, CZ, CY, FR, LV, MT, RO, TR; 2009: DE, EL, ES, HU, PL, SK.

Table 6 Overview of datasources available for the different lifestyle variables needed. Alcohol

Source	**Variable**	**Year (most recent)**	**Countrie s**	**Comment s**	
Eurostat [2]					
EHIS [2]	ECHI46 and 47	2006-2010	Limited[1]	2nd wave in 2014	By gender and age (8 cats)
Eurobarometer [12]	Liters per capita, adults, 15+, categories of average daily consumption	2009	EU27 (Misses HR, NO,ICE)	About 1000 respondents per country	By gender and age, but small numbers
WHO Global Alcohol database	Liters per capita, adults, 15+.	Varies	EU28, NO, ICE	Trends 1990-2010: Status report 2013.	
EUSAH/EISAH/GISAH WHO+EU [10] (http://who.int/gho/eisah).	Liters per capita, adults, 15+.	2008, 2011, 2012.	Worldwide		By age and gender
WHO HFA DB [9]	Liters per capita. Adults 15+.	2005	Worldwide	Based on national surveys, first source for Anderson and Blaumberg	Only by age by reference to national surveys.
OECD Health data [7]		2009-2012	Limited	Incomplete regarding countries	Not by age? By gender
CAMH report (Rehm et al. 2012)	Liters per capita, adults, 15+ and average daily consumption in categories	2009	EU27 +NO+ICL -HR-Lie.	Not clear about actual reference year of data, own calculations added to data	Must be by age and gender.

Further notes concerning Alcohol

Reports consulted: Committee, EU 2010, Anderson and Blaumberg 2006, Anderson et al. 2012, Horlings and Scoggins (2006), Rehm et al. (2012), WHO 2013, Tuomi-Nikula et al. 2012. Eurobarometer 331, 2010. In addition online databases were directly consulted.

“The best indicator for overall volume of alcohol consumption is adult (age 15+ years) per capita consumption (Gmel & Rehm, 2004), as it avoids the various biases introduced by current surveys of the general population (for example, Groves, 2004; Shield & Rehm, 2012).” (from WHO 2012).

Non-drinkers are to be split into never drinkers and former drinkers. Occasional drinkers (Allemani 2001) may differ per culture.

Underreporting up to 60% (Bloomberg 2003). Assume this to be constant over countries.

Table 7 Overview of datasources available for the different lifestyle variables needed. Overweight

Source	Variable	Year (most recent)	Countries	Comments	
Eurostat [2]					
EHIS [2]	ECHI42	2006-2010	Limited[1]	2nd wave in 2014	By gender and age (8 cats)
WHO GHO [14]	Overweight, Obesity, Mean BMI	2008	EU28+NO,IS. Not LI		
IASO report [12]	BMI categories	2008	Limited	Calculated data based on national surveys Reference years may vary.	Not clear about age categories.
OECD Health data [7]		2009-2012	Limited	Incomplete regarding countries	Not by age? By gender

Further notes concerning overweight
Reports consulted for overweight. OECD 2012, Sassi 2010, IASO 2012 [12]. In addition online databased were consulted.

Important distinction between self-reported and measured BMI. Most surveys use self-reported BMI, IASO data repository provides a distinction, but is incomplete.

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Study Design for review purposes, reply form

"Life Table Analysis: health system cost-effectiveness assessments across Europe"

Tender n° EAHC/2013/Health/05

Contract notice 2013/S 043143 of 27/03/2013

by
National Institute for Public Health and the Environment (RIVM), in cooperation with ErasmusMC and Erasmus University.

Bilthoven, The Netherlands, January, 2013.

Reply form

Our question to you as a reviewer is to comment on the study design, focusing on those parts that concern your expertise. To enable finding these parts, we have made ample use of subheadings throughout the text. That is, we do not expect you to comment on the entire text, although you may of course feel free to do so.

It is important to keep in mind that the current research project will have a limited budget and time horizon of 12 months. Nevertheless, the results have to be sufficiently reliable and enable sound interpretation.

Contact: Talitha.Feenstra@rivm.nl, or Richard.Heijink@rivm.nl.

Your area(s) of expertise:	
Do you agree with the approach proposed? Please comment your answer.	
Do you agree with the data sources proposed? Please comment your answer. Did we miss important data sources?	
Do you agree with the output measures proposed? Please comment your answer.	
What could be advantages of the current approach?	
What could be important limitations?	

What are caveats to be aware of? E.g. risks of bias to take into account.
Do you have suggestions regarding references or experts to consult?
Any further comments or remarks?

Thank your for your efforts.

"Life Table Analysis: health system cost-effectiveness assessments across Europe" (MACELI)
Contract 20136303 Call for tenders EAHC/2013/Health/05
Results of expert review of study design.

List of experts consulted and responses.

In total 19 experts were approached, of which 10 confirmed their participation in December. From 7 of these, we received a timely and complete review. One of them withdrew in second instance, one could not make it in time due to problems of receiving the design to the right address and one did not respond. In addition we approached our advisory board with an open opportunity to comment, resulting in one further review.
Areas of expertise covered were using experts' own wordings: Public health technology assessment, Economic evaluation, Outcome measurement, Obesity epidemiology, Public health, Life table modeling, Demography, Health economics, Macroeconomics, Health care at macro level, Efficiency analysis, Global health, Medical demography, and Social epidemiology.

Table 3: Overview of experts involved in review of study design

Experts approached		Participation confirmed	Review received
Name	Affiliation	10	7
Prof A Street	University of York, UK		
Prof M McKee	LSHTM, UK	Replacement proposed	
Prof U Hakkinen	National Institute for Health and Welfare, Finland		
Dr E Nolte	RAND Europe, UK	1	Problem with email on our side
Prof A Ludbrook	University of Aberdeen, UK		
Dr S Cnossen	CPB, Netherlands	1	Withdrawn
Prof J Seidell	VU University Amsterdam, Netherlands		
Dr A Peeters	Monash University, Australia	1	1
Dr C van Ewijk	CPB, Netherlands	1	1
Prof Dr T Vos	IHME, University of Washington, USA	1	1
Prof F Willekens	RUG/NIDI, Netherlands	1	1
Dr J Lauer	WHO	1	
Prof S Evers	Maastricht University, Netherlands	1	1
Prof M Lindenboom	University of Amsterdam, Netherlands	Replacement proposed	
Prof J Barendregt	University of Queensland, Australia		
Anton Kunst	University of Amsterdam, Netherlands	1	1
Dan Chisholm	WHO		
Franco Sassi	OECD		
Adriana Castelli	University of York, UK	1	1

Summary of comments

The complete overview of all comments can be found in a separate excel document. From these we extracted the following main comments.

Several reviewers asked more clarification on the approach to standardizing for lifestyle differences on both health outcomes and health care spending. In addition, some reviewers critiqued this double standardization approach, while others considered this as of great value, especially the use of DYNAMO-HIA. Thus opinions were mixed on this topic.

More general comments on the study approach were suggestions to include explicit uncertainty analyses by several reviewers, to remove Liechtenstein, to add a discussion of strengths and limitations, to reconsider using the RIVM framework in the qualitative analyses and to change the order of the qualitative and quantitative analysis.

Two more specific comments on the definition of lifestyle scenarios were given. A reviewer asks what would be the healthy reference category in alcohol and overweight. Another point is the definition of scenarios with stepwise increases on multiple categories.

Regarding the regression analyses, several reviewers suggested use of spending per capita or spending adjusted with PPP. Three reviewers had problems with the regressions as such, but for varying reasons. Caution in the interpretation was also suggested.
More specifically, 5 reviewers suggested adding other covariates, while one warned against over controlling and suggested using country specific dummies.

The validation by a full analysis on NL and DE was critiqued by 4 reviewers as not helpful for the main objective.

Almost all reviewers expressed concerns for consistency in the data used and comparability across countries of the various variables. It was suggested to use statistical methods rather than expert opinion to correct for missing values. It was also suggested to show international patters in the raw data before proceeding with the analyses. Some comments concerned terminology and reporting of alcohol and overweight. One pointed at existing controversies in the value of relative risks for overweight.

Four reviewers underlined that the results of the project cannot be interpreted as cost-effectiveness ratios, since no interventions and costs of these are included. A reviewer thought life expectancy was a less appropriate measure to reflect the effect of health care spending, while the other two were better.

Some reviewers did not fully understand the objective of the project or commented it seemed like two objectives in one.
Several reviewers asked for more explanation on the use of DYNAMO HIA.

No alternatives for our data sources were mentioned, except the site of the IHME, which are the GBD data.

List of proposed adaptations in response to comments

Regarding comments on overall objective and the approach towards standardizing for lifestyle differences we propose that more clarification is the best way forward.
In addition, we consider a sensitivity analysis using a more common way to control for differences in life style, that is, by including covariates in the regression analyses, see below on the contents of the sensitivity analyses.

In addition, more elaborate uncertainty analyses would also be preferable, however, this would require time and probably the interim analyses will contain limited uncertainty analyses, to be followed by more elaborate ones in the final report.
We will consider removing Liechtenstein. Very few data will be available and this country deviates from the others, for its very open system. That is, many citizens will go to neighboring countries for part of their health care.
We will add strengths and limitations, as we planned to do, in the discussion chapter.

Regarding the definition of lifestyle scenarios, the reviewer is right that the category of non-use in alcohol and very low BMI in overweight are a mixture of abstainers and former drinkers. However, by using similar categories in SHARE when estimating odds ratios, risks in these categories will reflect the mixed populations.
Regarding scenarios, we will define these in terms of shifts towards a more healthy distribution over categories. We would however prefer to focus on the scenarios that are of interest to policy, like the most healthy country, the EU28 average, and the least healthy country.

Regarding the sensitivity analyses, we thought this over in reaction to the reviewer comments. Given the importance of consistency in data, we propose to replace the full evaluations of NL and DE by elaborate sensitivity analyses on the following points:

- Different way of accounting for lifestyle in the regressions: not by double standardization, but in the more common way by including it as a covariate.
- Use of a different set of input data on lifestyle, that is, the GBD data.
- For a limited set of countries, use of panel data in addition to the standard analyses.

Regarding the regression analyses, the reviewers opinions were mixed. We propose to better explain our approach and indeed use sufficient caution in the interpretation of the results. This concerns causality claims and interpretation as a cost-effectiveness ratio. However, we will review interventions and provide information on their costs and benefits.

Given that no substantial comments on our choice of data sources were given, we do not propose any changes here. However, we will remain aware of the consistency issues. We did not see very critical comments concerning time lags in lifestyle variables specifically, though the standardization and regression approach was commented (see above) and hence we will proceed as proposed in the study design by using the double standardization with age and gender specific data, as much as possible.

For the use of DYNAMO-HIA, more explanation will be added in the methods of the report, given the questions raised by the reviewers.

Conclusions

The main changes to the study design in response to the reviewer comments concern replacing the sensitivity analyses by those required for by the reviewers and being careful in the definition of the scenarios to be evaluated with DYNAMO-HIA.

Expert workshop, program, summary of results, and list of discussion points

The effect of lifestyle on health system efficiency. Methodological and policy issues.

Invitational Workshop as part of the EAHC tendered project: Macro Cost Effectiveness corrected for Lifestyle (MACELI).
Contract 20136303 Call for tenders EAHC/2013/Health/05 "Life Table Analysis: health system cost-effectiveness assessments across Europe". Funded by the European Union in the frame of the EU Health Programme (2008-2013)

LOCATION: Park Inn Radisson Brussels Midi
TIME: 11h00-16h00

Draft Program
10h30-11h00 Coffee.

11h00-11h15	Start of the workshop	Dr TL Feenstra
11h15-11h35	Introduction of participants	
11h35-11h40	Background of the EAHC call	Representative DG Sanco: Dr A Carvalho
11h40-12h20	MACELI main interim results	Dr PHM van Baal
12h20-13h00	Guest speaker	Prof M St Aubyn
13h00-14h00	LUNCH	

14h00-15h00 sub sessions
Each sub session will consist of two presentations of 15 minutes each explaining methods applied in the MACELI project in more detail. This is followed by extensive time for discussion.

1. *Use scenarios to standardize countries for differences in lifestyle*
   This sub session will address consistent prevalence estimates of lifestyle behavior, estimating and interpreting Odds Ratios for health outcomes related to lifestyle and the use of life table modeling to relate lifestyle scenarios to health outcomes. Special attention will go to having a look at the observed actual lifestyle results for all countries and the calculated odds ratios and their interpretation. The role of time lags will be addressed.
   Keywords: alcohol use, smoking, overweight, cross-country comparisons, odds ratios, self-reported health outcomes, life table modeling.

2. *Interpreting outcomes of efficiency frontiers*
   What is the best way to correct for differences in lifestyle when assessing the efficiency of health care systems? This subsession will cover in more detail the topics addressed in the morning. Different approaches to assessing health system efficiency and their (dis)advantages will be discussed. Furthermore, we will discuss the interpretation and usability of country-level comparisons and rankings of health system performance and the role of lifestyle and other environmental factors.
   Keywords: Regressions, DEA, covariates, stratification.

15h00-15h15	Tea break	
15h15-15h45	Plenary discussion	Prof Dr HM Boshuizen
15h45	Closure and drinks	

The effect of lifestyle on health system efficiency. Methodological and policy issues.

Invitational Workshop as part of the EAHC tendered project: Macro Cost Effectiveness corrected for Lifestyle (MACELI).
Contract 20136303 Call for tenders EAHC/2013/Health/05 "Life Table Analysis: health system cost-effectiveness assessments across Europe". Funded by the European Union in the frame of the EU Health Programme (2008-2013)

LOCATION: Park Inn Radisson Brussels Midi
TIME: 11h00-16h00

Summary of Results and action points

Organizers present

Pieter van Baal	Erasmus University
Michael van den Berg	RIVM(National Institute of public health and the environment)
Hendriek Boshuizen	RIVM(National Institute of public health and the environment)
Talitha Feenstra	RIVM (National Institute of public health and the environment)
Koen Fussenich	RIVM(National Institute of public health and the environment)
Richard Heijink	RIVM(National Institute of public health and the environment)
Petra Hoogerhuis	RIVM(National Institute of public health and the environment)
Wilma Nusselder	Erasmus Medical Centre
Ardine de Wit	RIVM(National Institute of public health and the environment)

Participants present and subsession attended.

		Sub session 1	Sub session 2
Henrik Brønnum-Hansen	University of Copenhagen	1	
Guy d' Argent	EAHC (Executive Agency for Health and Consumers)	1	
Arthur Carvalho	DG Sanco	1	
Marion Devaux	OECD (The Organisation for Economic Co-operation and Development)	1	
Gabriela Flores	University of Lausanne		1
Ulrich Frick	University of Zurich	1	
Eileen Kaner	Newcastle University	1	
Tim Lobstein	IASO (The International Association for the Study of Obesity)		
Pascal Meeus	INAMI (Belgian Health Insurance system)		1
Cor van Mosseveld	CBS (Statistics Netherlands)		1
Ivo Rakovac	World Health Organisation	1	
Francoise Renard	Scientific Institute of Public Health	1	
Jean-Marie Robine	French National Institute of Health and Medical Research	1	
Markus Schneider	Basys (Applied Systems Research Consulting Corporation Ltd)		1
Miguel St. Aubyn	UECE-ISEG, University of Lisbon		1
Dirk van der Steen	DG Sanco		1
Michael Stolpe	Kiel Institute for the World Economy		1
Tommy Visscher	Windesheim University of Applied Sciences		
Matthias Vogl	Helmholtz Zentrum München	1	

Summary of morning session.

11h00-11h15	Start of the workshop	Dr TL Feenstra
11h15-11h35	Introduction of participants	
11h35-11h40	Background of the EAHC call	Representative DG Sanco: Dr A Carvalho
11h40-12h20	MACELI main interim results	Dr PHM van Baal
12h20-13h00	Guest speaker	Prof M St Aubyn

All presentations were received with a lively discussion in the audience.

Afternoon session.

14h00-15h00	sub sessions
15h00-15h15	Tea break
15h15-15h45	Plenary discussion

Both sub sessions were well attended, with slightly more participants in the first sub session. From the subsessions, two lists of suggestions and points for discussion result. Additionally in the plenary discussion two points brought up were:

- Pay attention to relations between BMI/Smoking/Alcohol in the discussion.
- Message of costly, but cost-effective results quite hard to explain for a wide audience. May use disease-specific modeling to explain this better.

Action points for the MACELI Team

- Adjust policy setting to new EU policy documents as presented by A. Carvalho.
- Use discussion of DEA approach by St Aubyn in chapter on methods, when explaining the different approaches towards assessing health system efficiency.
- Use points on lists of suggestions to improve the discussion and as input for the qualitative chapter. Put interim results into their appropriate perspective.

Long list of discussion points workshop.

- Health care spending is chosen as dependent variable, alternative would have been use of health services
- Baseline scenario to be understood as current level of interventions available to prevent and treat diseases related to unhealthy lifestyle, not as a baseline scenario as used by WHO.
- Impact of clustering of smoking and BMI. Correction for clustering of smoking and BMI, we did not do that, but data were robust enough not to expect large impact of clustering.
- Limitation that SHARE concerns only 50+ persons, overestimation of effects because data from older people are used.
- delay between health behavior and its consequences.
- use EHIS health interview survey for sensitivity analysis?
- differences in OR as used from international literature, may especially be influential for the disability estimates. Reduced OR for younger people?
- Separate scenarios for smoking and obesity and impact on cost estimates, explain and discuss finding that reduction in risky behavior results in higher health care costs. Expectation that separate analysis for obesity would reduce healthcsre spending instead of augmenting it
- Discuss the notion of differences between demand or need for health care? Self perceived health how does that relate to needs? If you are rich, more demand.
- Preference for use of data on occurrence of chronic diseases, rather than perceived health. Possibility to use European harmonized data on occurrence of chronic diseases?
- DALY could have been an interesting outcome
- discuss the difference between current use of data on curative health expenditure instead of data on preventive health expenditure?
- It may take time to see effects of lower spending in le
- What is best performer spending..? Om prevention?
- Explain standardisation
- Share 50+
- Compare model results to observed results? In addition to cau observed vs scenario outcomes.
- Period not cohort
- Le at birth vs share with age 50+, suggestion use model for 50+ as a SA
- For disability, lit uses different outcomes.
- Wat is er voor verschil tussen de 2 plaatjes in % verschil in le?
- Outcome, considered DALYs, more layers. This is just a one period outcome.
- Zit op de le vs volume punt van Peter Achterberg
- Why no within countrry comparisons
- Volumes vs expenditure. Price is an outcome of the health system.
- Alcohol results based in limitations of dataset?

Suggestions from subsession 1.

Main points for policy implications and discussion:

- Drinking patterns are important
- The causal pathway for alcohol in relation to health care use is sometimes unexpected, due to care avoidance and rationing.
- Pay attention to model validation and uncertainty of outcomes.
- A trade-off exists between high quality data and including a large range of countries.

Main points for methodology and further research:

- Better prevalence data on alcohol could be interesting, but have to match with self reported data used to find ORs.
- Compare the results assuming a fixed age pattern with those obtained now.
- Consider the possibility to restrict the analyses to the age group of 50+.
- Try using cross tabulation to get information on patterns for alcohol use from EB data.

- Consider applying SHARE waves to get insight into time effects of lifestyle variables.
- Evaluate an additional scenario that results in 2 more HLY in 2020, since that is a EU goal.
- Use disease free life expectancy as an outcome (ECHO) in further research.

Other points discussed.

- Take the US and Australian literature on interventions and k/e into account. Check the recent OECD literature review on alcohol interventions. Focus on interventions at a system level, rather than interventions targeting individuals.
- Use the 2010 paper by Lim et al. to justify the choice of lifestyle risk factors.
- Include a thorough explanation of choices made concerning alcohol data and how these were used in the analyses.
- Use the findings from the project for recommendations concerning new data gathering: what deserves special attention in a next Eurobarometer? What are recommendations for other data gathering efforts ongoing with EU support?
- Discuss choices concerning ORs. Alternative choices could have been made.
- For further research, an approach using disease specific data could use ECHO data .

Suggestions from subsession 2.

Main points for policy implications and discussion:

- If system performance improves, GDP rises.
- Within country variations
- Many returns of spending not measured/not included in the outcomes.
- Is healthy life style an intermediating variable or an exogenous variable.

Main points for methodology and further research

- Time lags
- Other input measures such as number of doctors, beds, etc., not only expenditure
- Correct for wage level differences
- Correct for population density
- Include capital investment?
- Interaction between age and BMI
- Correct for public health activities?
- Health expenditure not broken down by spending per age group
- Interactions between age and BMI not taken into account
- Year 2009 GDP data different? Exclude 2009 or other recession years?

General discussion

- Pay attention to relations between BMI/SMOK/Alc in the discussion.
- Message of costly, but cost-effective results too hard for wide audience? Use disease-specific modeling to explain this better. Showing effects on competing diseases will make results less counterintuitive
- Can we use data of Health Matrix (risk factors)? Use GBD data as a justification for our choice of lifestyle behaviors
- Group interventions in review in individual and collective interventions. System policy level interventions will also be helpful, now not included in review. Literature review should be extended to Australia and Canada
- Other points brought forward, to be discussed in final report:
    - Those who stop smoking will step into other addictions, less room for change than suggested
    - Behaviors not isolated, cumulative effects, model assumes multiplicative effects

9.7 Selected results for the EU-28 Member States

This appendix contains a selection of the graphs and tables from Chapter 4 for the EU-28 Member States.

Results of unadjusted analyses.

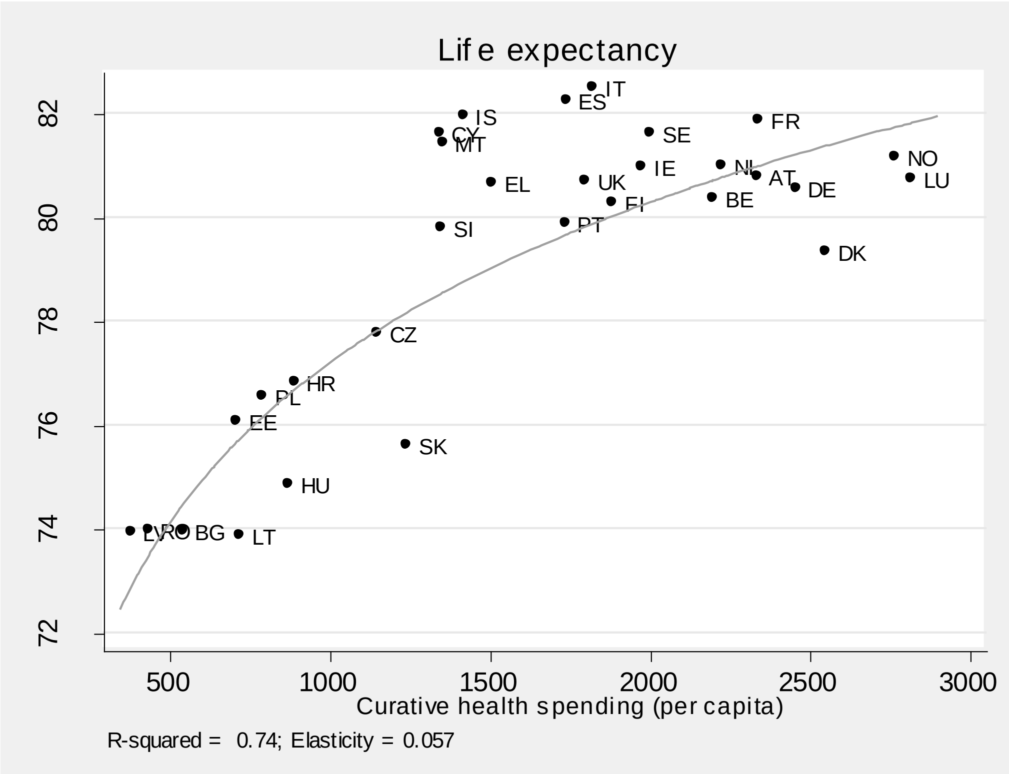

Figure 9.5: The association between curative care spending and life expectancy

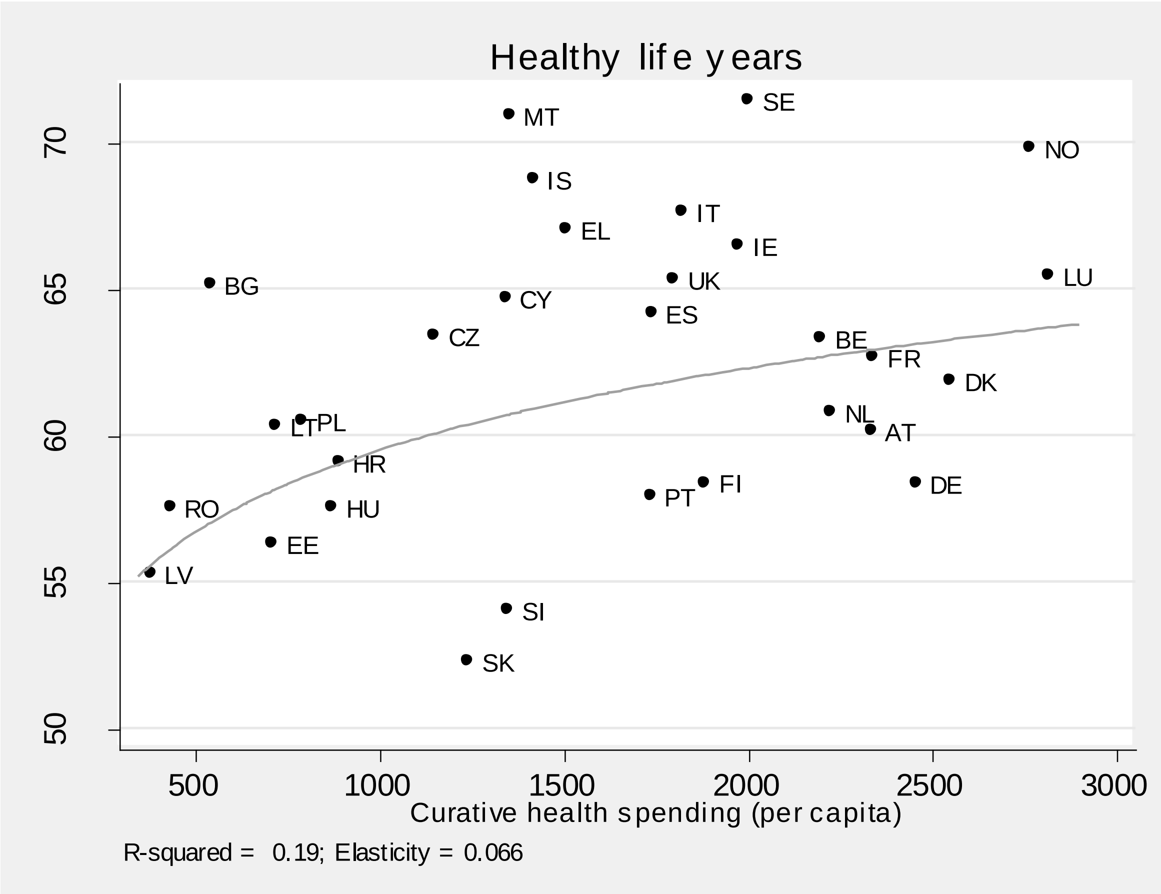

Figure 9.6: The association between curative care spending and healthy life years

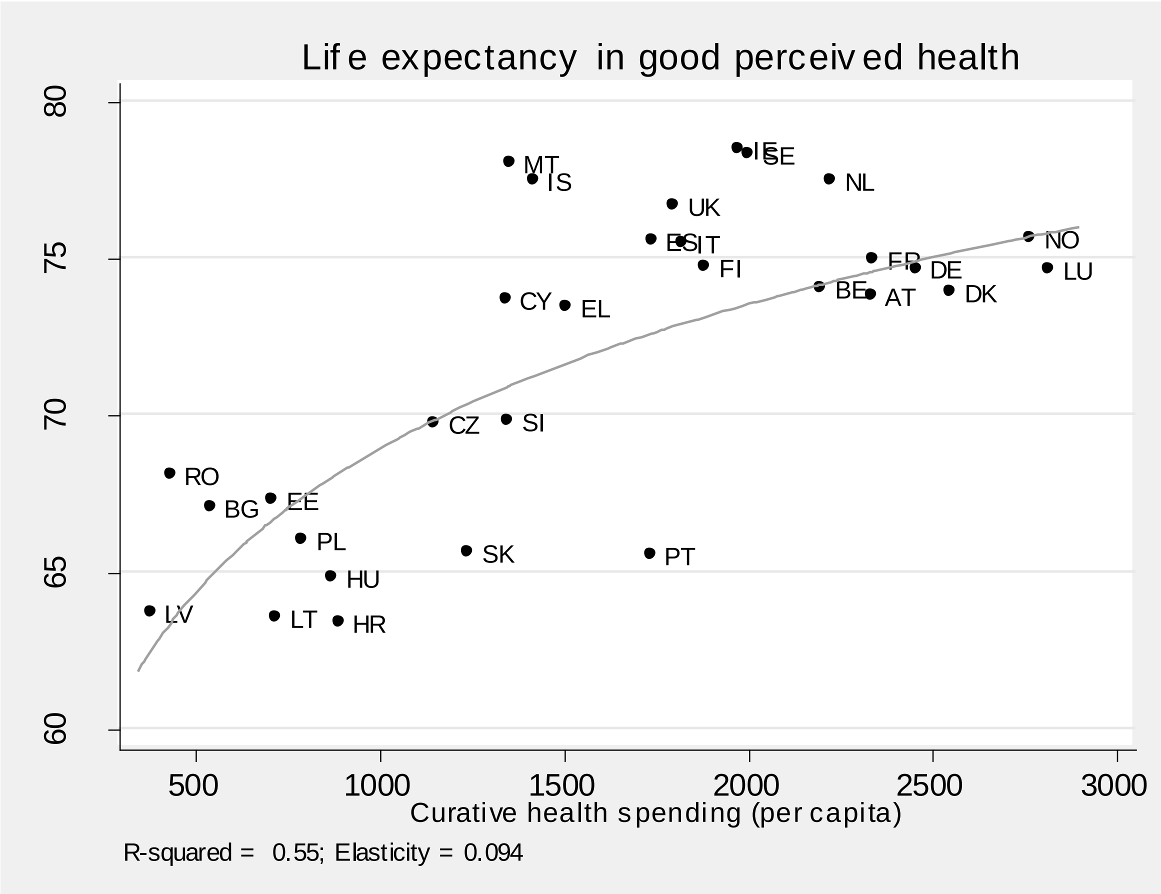

Figure 9.7: The association between curative care spending and life expectancy in good perceived health.

Table 9.2: Elasticity of population health to curative care spending, GDP per capita and education

	LE	HLY	LEGPH
Basic model (2010)			
Curative care spending	0.055***	-0.076	0.053
GDP per capita	0.000	0.180	0.055
Education	-0.022	-0.031	0.018
N	21	21	21
R-squared	0.76	0.30	0.58
Panel data model (2004-2011)			
Curative care spending	0.031***	-0.174***	0.103***
GDP per capita	-0.022**	0.097**	-0.059***
Education	0.131***	0.311**	0.252***
N	179	164	164

P-value of null hypothesis of no effect. *p<0.10; **p<0.05; ***p<0.01

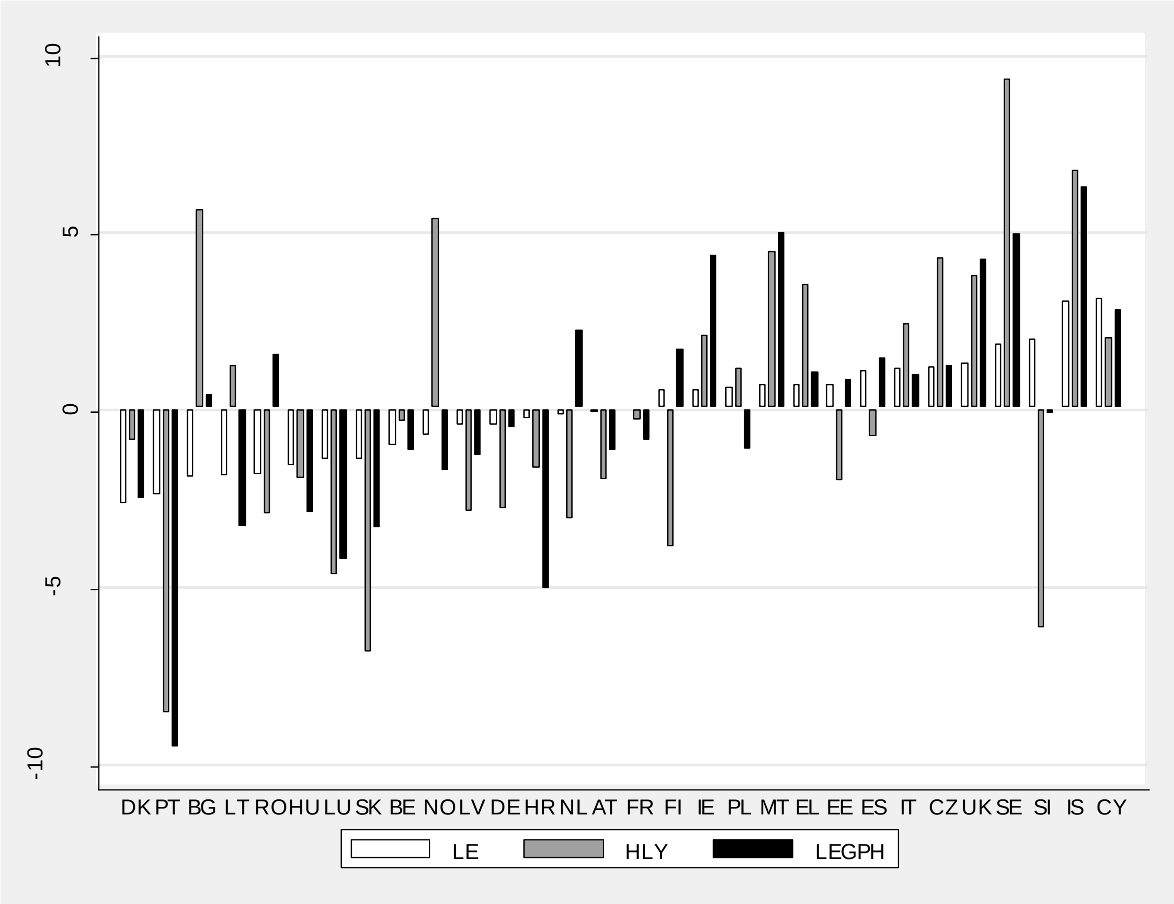

Figure 9.8: Health system efficiency estimated by parametric analysis (actual-predicted population health in years)

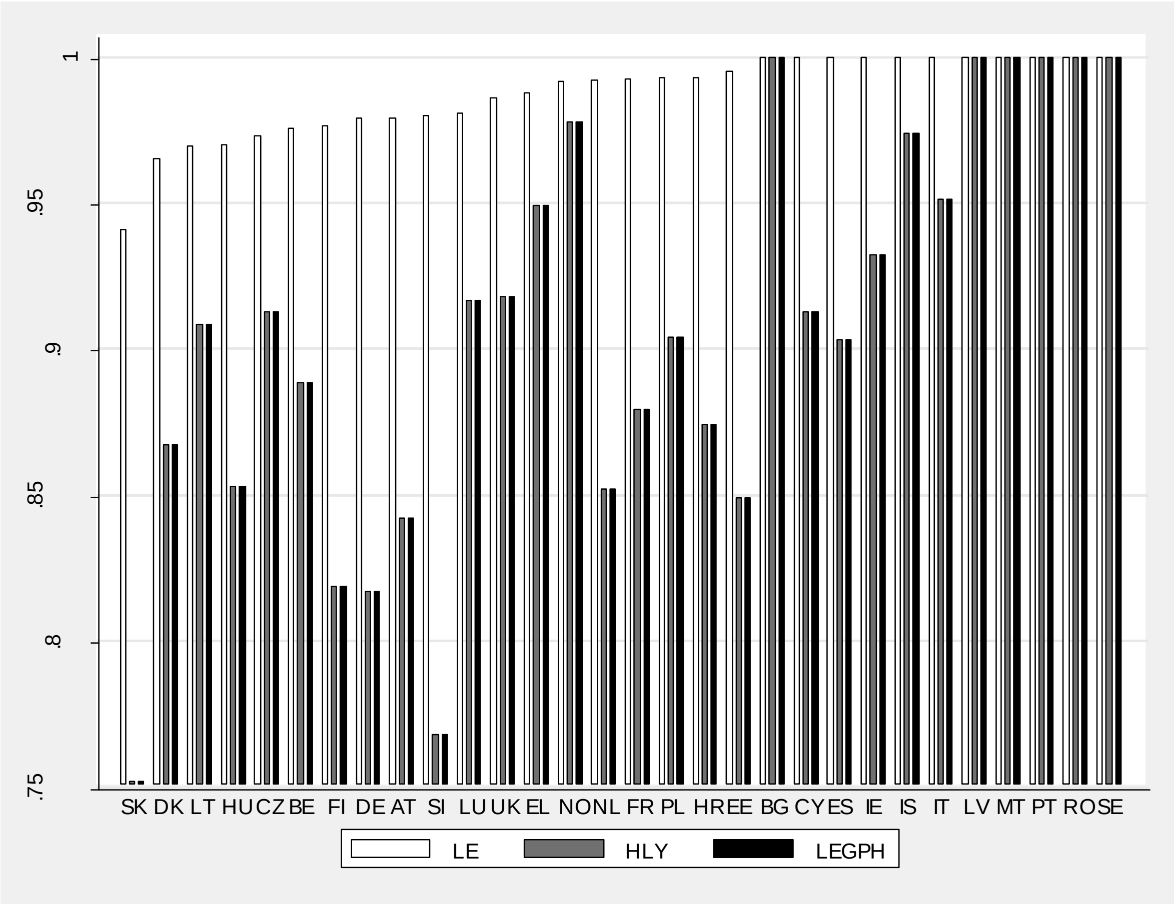

Figure 9.9: Health system efficiency estimated by Data Envelopment analysis (efficiency score between 0 and 1).

The same figure has also been split into three separate figures, one for each health outcome and with countries ordered by efficiency.

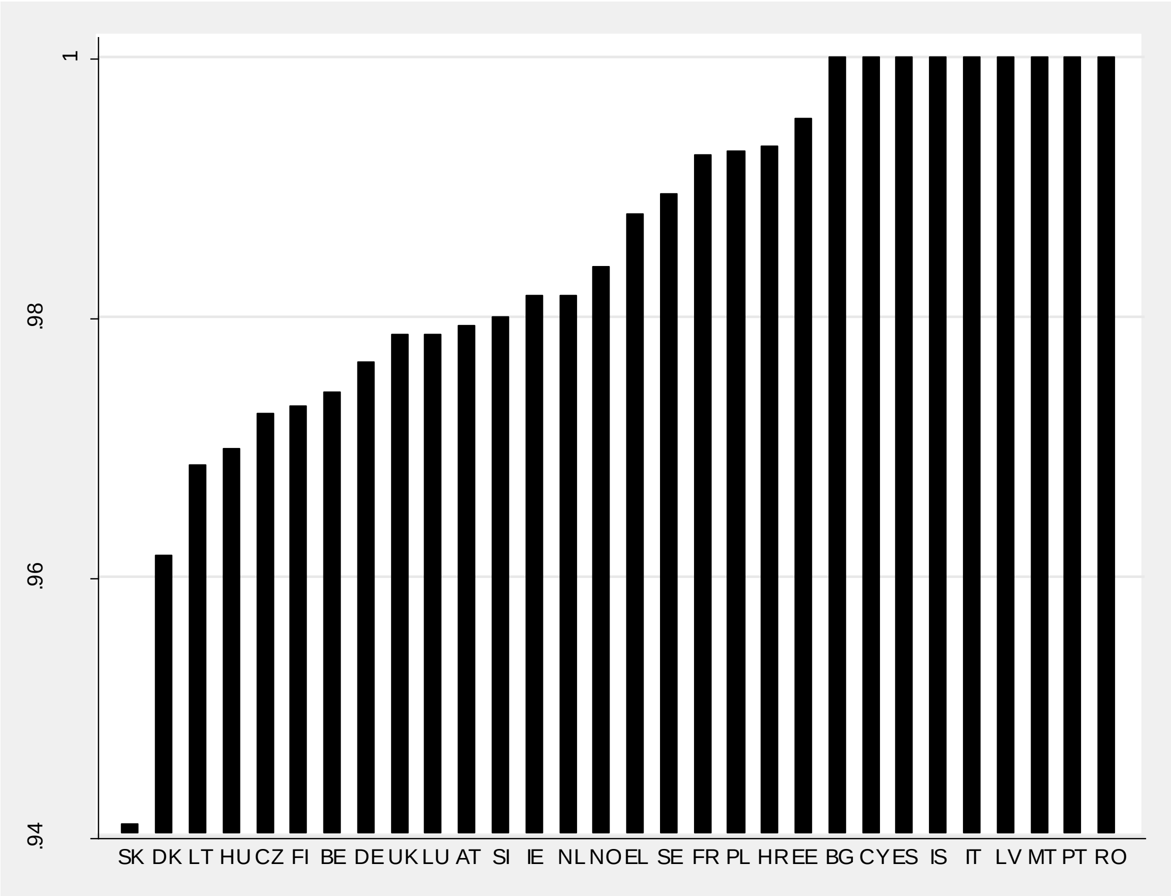

Figure 9.10: Health system efficiency estimated by Data Envelopment analysis (efficiency score between 0 and 1), using Life Expectancy as health outcome.

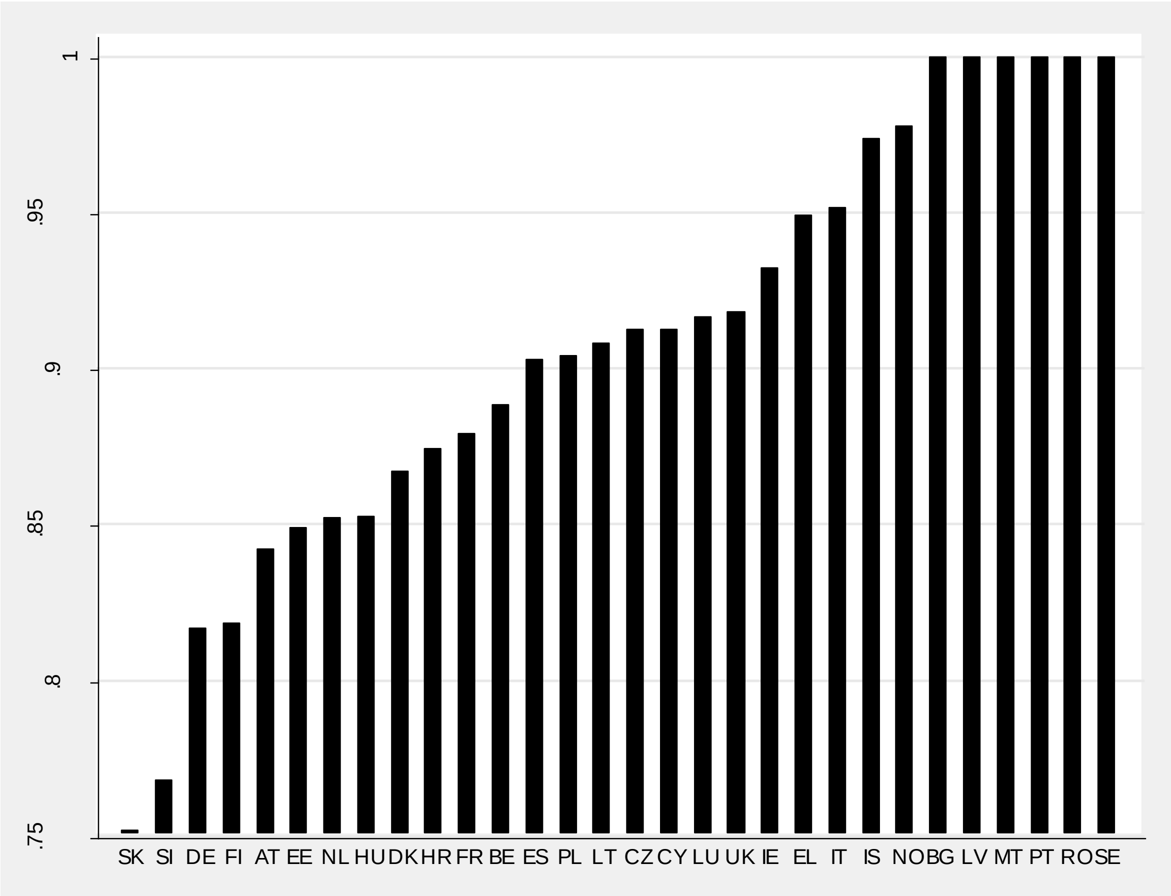

Figure 9.11: Health system efficiency estimated by Data Envelopment analysis (efficiency score between 0 and 1), using Healthy Life Years as health outcome.

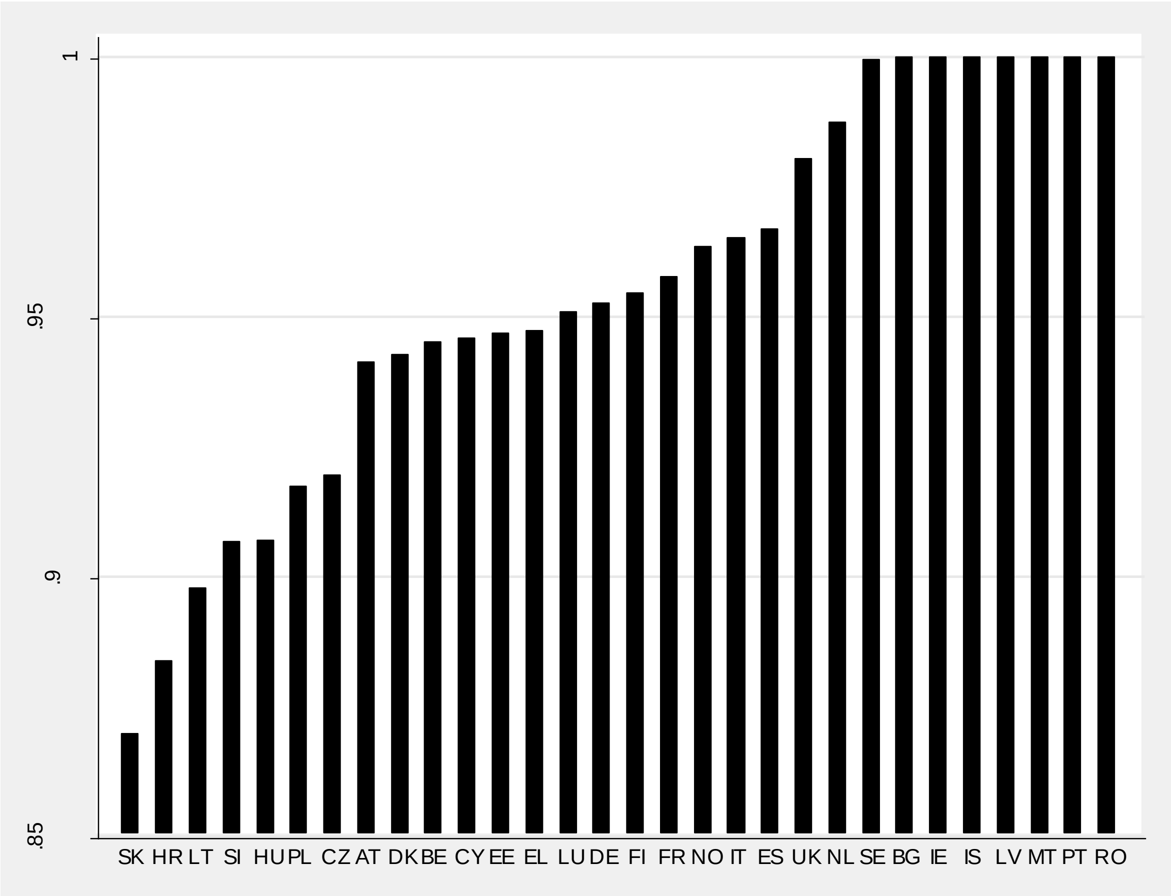

Figure 9.12: Health system efficiency estimated by Data Envelopment analysis (efficiency score between 0 and 1), using Life Expectancy in Good Perceived Health as health outcome.

Results of scenario analyses.

Table 9.3: Baseline values for health spending and population health

Country	LE	LEGPH	HLY	THCE (€)
Austria	80.45	58.33	59.60	2339.46
Belgium	80.05	60.53	62.94	2201.44
Bulgaria	73.81	54.95	64.76	545.69
Croatia	76.65	58.37	58.37	893.62
Cyprus	81.15	59.73	64.79	1347.31
Czech Republic	77.57	53.44	62.69	1152.76
Denmark	79.24	58.30	60.74	2553.83
Estonia	75.98	46.11	55.61	713.23
Finland	80.01	58.11	57.08	1886.45
France	81.34	56.91	62.17	2344.18
Germany	80.49	56.25	61.98	2460.08
Greece	80.50	62.65	66.65	1512.03
Hungary	74.54	47.35	56.93	875.28
Ireland	80.81	67.12	65.96	1979.02
Italy	82.13	58.16	67.33	1825.51
Latvia	72.90	41.63	54.19	382.25
Lithuania	73.16	45.15	59.63	722.84
Luxembourg	80.45	61.46	64.89	2821.36
Malta	80.71	56.10	70.49	1358.14
Netherlands	80.77	64.30	60.40	2229.57
Poland	76.30	48.32	59.76	793.41
Portugal	79.93	43.83	57.23	1739.92
Romania	73.77	54.96	57.08	436.00
Slovakia	75.46	50.57	51.68	1243.42
Slovenia	79.52	50.30	52.81	1351.82
Spain	82.04	59.97	63.59	1743.38
Sweden	81.52	66.71	70.80	2004.78
United Kingdom	80.40	65.07	64.50	1802.92

Table 9.4: Changes in health and health expenditures in scenario 1 compared to the base case scenario

	Difference between scenario 1 and base case scenario			
Country	LE (years)	LEGPH (years)	HLY (years)	TCHE* (€)
Austria	0.95	2.98	2.18	38
Belgium	1.11	3.21	2.21	31
Bulgaria	1.31	2.77	2.19	10
Croatia	1.65	3.77	4.91	30
Cyprus	1.21	3.90	2.90	23
Czech Republic	1.21	3.90	2.90	21
Denmark	1.41	2.67	2.00	60
Estonia	1.66	3.79	2.99	19
Finland	0.85	3.16	2.86	15
France	1.05	2.73	1.69	39
Germany	1.15	3.46	2.34	35
Greece	1.80	3.73	2.71	33
Hungary	1.67	4.14	3.26	19
Ireland	0.63	2.93	2.15	21
Italy	0.36	2.59	1.58	14
Latvia	2.25	4.87	3.99	13
Lithuania	1.89	3.58	3.23	21
Luxembourg	1.14	3.32	2.37	50
Malta	1.26	4.95	3.00	13
Netherlands	1.38	2.68	2.14	52
Norway	2.14	3.66	3.07	95
Poland	1.86	3.74	3.36	22
Portugal	0.65	3.75	2.73	12
Romania	1.38	2.75	2.46	11
Slovakia	1.30	2.79	2.30	20
Slovenia	1.20	3.42	2.79	24
Spain	1.21	4.38	3.25	29
Sweden	0.66	1.25	0.92	26
United Kingdom	0.99	3.22	2.42	21

*Total curative care spending (€ per capita, price level 2010)

Table 9.5: Changes in Life Expectancy (years) by country and scenario

Scenario no[7]	2a	2b	2c	2d	3a	3b	3c	3d
Austria	3.09	1.79	1.24	0.07	-6.27	-3.75	-3.13	-0.04
Belgium	3.30	1.95	1.27	0.09	-6.29	-3.78	-3.15	0.01
Bulgaria	3.74	2.16	1.57	0.02	-6.07	-3.67	-3.19	0.01
Croatia	4.03	2.11	1.79	0.06	-5.64	-3.70	-2.60	0.07
Cyprus	3.18	1.80	1.32	0.03	-5.44	-3.38	-2.58	-0.01
Czech Republic	3.42	1.77	1.59	0.04	-6.26	-3.96	-2.97	-0.02
Denmark	3.65	2.37	1.20	0.12	-6.08	-3.51	-3.34	0.02
Estonia	4.31	2.43	1.77	0.03	-6.35	-3.82	-3.42	0.03
Finland	3.07	1.62	1.41	0.04	-6.52	-4.10	-3.12	0.00
France	3.34	1.94	1.32	0.09	-6.66	-3.99	-3.37	0.00
Germany	3.83	2.33	1.32	0.07	-6.51	-3.95	-3.33	-0.06
Greece	3.95	2.26	1.63	0.05	-5.34	-3.29	-2.69	0.03
Hungary	4.43	2.37	1.97	0.00	-6.36	-4.07	-2.99	0.03
Iceland	3.98	2.02	1.77	0.15	-4.82	-3.21	-2.26	0.18
Ireland	2.73	1.44	1.19	0.09	-6.55	-4.14	-3.03	0.01
Italy	2.42	1.33	0.99	0.10	-6.65	-4.07	-3.02	-0.08
Latvia	5.05	2.97	1.98	-0.01	-6.04	-3.55	-3.30	0.06
Lithuania	4.70	2.51	2.11	0.00	-6.50	-4.04	-3.45	0.12
Luxembourg	3.08	1.75	1.34	0.04	-5.87	-3.60	-2.81	0.01
Malta	3.29	1.38	1.79	0.02	-5.62	-3.95	-2.16	0.05
Netherlands	3.47	2.12	1.21	0.15	-5.79	-3.43	-3.00	0.04
Norway	4.23	2.25	1.75	0.17	-5.14	-3.31	-2.55	0.19
Poland	4.46	2.71	1.67	0.03	-6.12	-3.59	-3.23	0.00
Portugal	2.89	1.40	1.38	0.07	-6.78	-4.32	-2.99	0.00
Romania	4.19	2.27	1.71	0.10	-6.60	-4.09	-3.36	0.07
Slovakia	3.83	2.09	1.64	0.03	-6.29	-3.91	-3.03	-0.02
Slovenia	3.47	1.62	1.77	0.05	-6.13	-4.06	-2.67	0.02
Spain	3.34	1.78	1.45	0.07	-5.97	-3.79	-2.65	0.00
Sweden	2.71	1.63	1.02	0.05	-6.43	-3.83	-3.14	-0.07
UK	3.16	1.79	1.26	0.13	-6.38	-3.96	-3.09	0.04

[7] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption

Table 9.6: Changes in Healthy Life Years (years) by country and scenario[8]

	2a	2b	2c	2d	3a	3b	3c	3d
Austria	6.57	2.30	2.49	1.78	-14.78	-2.79	-7.53	-3.63
Belgium	6.48	2.20	2.66	1.74	-14.84	-3.18	-7.37	-3.39
Bulgaria	5.60	2.13	2.36	1.15	-9.82	-2.73	-5.23	-1.78
Croatia	7.84	2.36	3.43	2.12	-10.61	-2.49	-5.58	-2.43
Cyprus	6.55	2.01	2.82	1.80	-11.42	-2.44	-5.63	-2.67
Czech Republic	6.23	1.95	2.83	1.40	-12.96	-3.05	-6.15	-2.90
Denmark	7.02	3.20	2.81	1.18	-19.27	-4.02	-8.90	-4.89
Estonia	7.20	2.39	2.82	1.84	-12.66	-2.41	-6.37	-2.93
Finland	7.62	2.23	3.33	2.12	-16.37	-3.55	-7.85	-3.98
France	5.95	2.16	2.42	1.47	-15.35	-2.97	-7.70	-3.85
Germany	6.68	2.31	2.57	1.82	-14.43	-2.94	-7.28	-3.34
Greece	5.81	1.81	2.53	1.39	-8.19	-1.77	-4.39	-1.97
Hungary	7.21	2.09	3.03	2.02	-10.69	-2.56	-5.66	-2.16
Iceland	7.31	2.49	3.94	0.97	-14.99	-3.32	-6.12	-3.94
Ireland	6.26	1.78	2.46	2.09	-14.05	-3.59	-6.83	-2.61
Italy	5.22	1.37	1.76	2.13	-12.34	-2.99	-6.71	-2.08
Latvia	8.06	2.73	3.21	1.96	-11.27	-2.06	-5.92	-2.43
Lithuania	7.00	2.21	3.01	1.62	-9.88	-2.45	-5.30	-1.82
Luxembourg	6.56	2.27	2.99	1.49	-14.69	-3.31	-7.10	-3.51
Malta	6.20	1.44	3.16	1.55	-8.78	-2.96	-4.10	-1.55
Netherlands	6.70	2.50	2.77	1.48	-16.39	-3.07	-7.82	-4.34
Norway	7.28	2.91	3.70	0.75	-15.62	-3.53	-6.34	-4.00
Poland	7.45	2.48	2.75	2.07	-11.62	-2.47	-6.23	-2.23
Portugal	6.81	1.71	2.68	2.44	-13.12	-2.90	-7.07	-2.61
Romania	6.35	1.95	2.43	1.82	-10.51	-2.46	-5.81	-2.10
Slovakia	5.99	1.88	2.40	1.68	-11.92	-2.19	-5.75	-2.90
Slovenia	7.65	2.20	3.42	1.96	-16.07	-3.36	-7.53	-4.24
Spain	7.33	2.08	2.91	2.29	-12.72	-2.65	-6.56	-2.62
Sweden	4.83	1.82	2.08	1.01	-15.88	-4.06	-7.27	-3.13
UK	6.68	2.16	2.74	1.96	-14.72	-3.48	-7.22	-3.22

[8] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption

Table 9.7: Changes in Life Expectancy in Good Perceived Health (years) by country and scenario[9]

	2a	2b	2c	2d	3a	3b	3c	3d
Austria	8.40	3.04	2.90	2.52	-19.31	-4.54	-11.16	-3.59
Belgium	8.69	3.04	3.44	2.40	-19.94	-5.22	-10.64	-1.89
Bulgaria	6.51	2.37	2.51	1.70	-11.96	-2.82	-6.86	7.66
Croatia	9.80	3.11	4.14	2.73	-14.14	-4.22	-7.59	-2.95
Cyprus	8.29	2.56	3.42	2.38	-14.12	-3.68	-7.37	2.00
Czech Republic	7.17	2.36	2.79	1.89	-15.91	-3.86	-8.92	5.41
Denmark	9.03	3.90	3.63	1.73	-24.53	-6.19	-13.52	-3.99
Estonia	9.14	3.11	3.07	2.55	-16.92	-4.17	-10.34	5.65
Finland	8.19	2.50	3.49	2.29	-17.77	-4.76	-9.44	-6.19
France	8.39	3.09	3.17	2.28	-20.86	-5.03	-11.88	0.30
Germany	9.31	3.21	3.38	2.68	-19.81	-5.12	-11.23	1.42
Greece	7.53	2.51	3.20	1.91	-11.49	-2.78	-6.05	1.67
Hungary	8.56	2.64	2.97	2.74	-13.05	-3.48	-7.77	6.94
Iceland	8.79	3.12	4.81	1.21	-20.34	-5.30	-9.09	-5.07
Ireland	7.77	2.39	3.08	2.66	-19.12	-5.67	-9.73	-4.45
Italy	7.41	2.05	2.20	3.20	-17.49	-4.60	-9.79	6.58
Latvia	9.94	3.59	3.12	2.69	-14.54	-3.31	-9.41	9.35
Lithuania	7.82	2.68	2.82	2.04	-13.30	-3.11	-8.15	12.10
Luxembourg	8.50	2.87	3.80	2.10	-18.79	-5.00	-9.74	-4.58
Malta	9.83	2.39	4.46	2.92	-15.62	-4.53	9.41	12.58
Netherlands	7.98	3.08	3.31	1.80	-21.23	-5.22	-15.83	-9.66
Norway	8.70	3.44	4.55	0.98	-21.20	-5.54	-9.59	-5.14
Poland	8.36	2.88	2.57	2.56	-14.48	-3.39	2.52	8.57
Portugal	8.81	2.59	2.57	3.53	-16.27	-4.65	3.54	10.04
Romania	6.79	2.18	2.48	2.03	-11.65	-3.22	-6.64	-0.62
Slovakia	7.22	2.30	2.67	2.07	-14.57	-3.76	-8.19	-2.73
Slovenia	9.20	2.83	3.73	2.46	-19.03	-5.07	-9.74	-3.26
Spain	9.47	2.79	3.54	3.15	-16.67	-4.28	-5.69	0.35
Sweden	6.56	2.13	2.84	1.70	-23.57	-6.42	-6.14	-0.01
UK	8.22	2.80	3.47	2.35	-19.22	-5.45	-10.47	-4.63

[9] Scenario definitions were 2a: 100% healthy; 2b: 100% no smoking; 2c: 100% best BMI; 2d: 100% in healthiest category for alcohol consumption; 3a: 100% unhealthy; 3b: 100% smoking; 3c: 100% worst BMI; 3d: 100% most unhealthy category for alcohol consumption

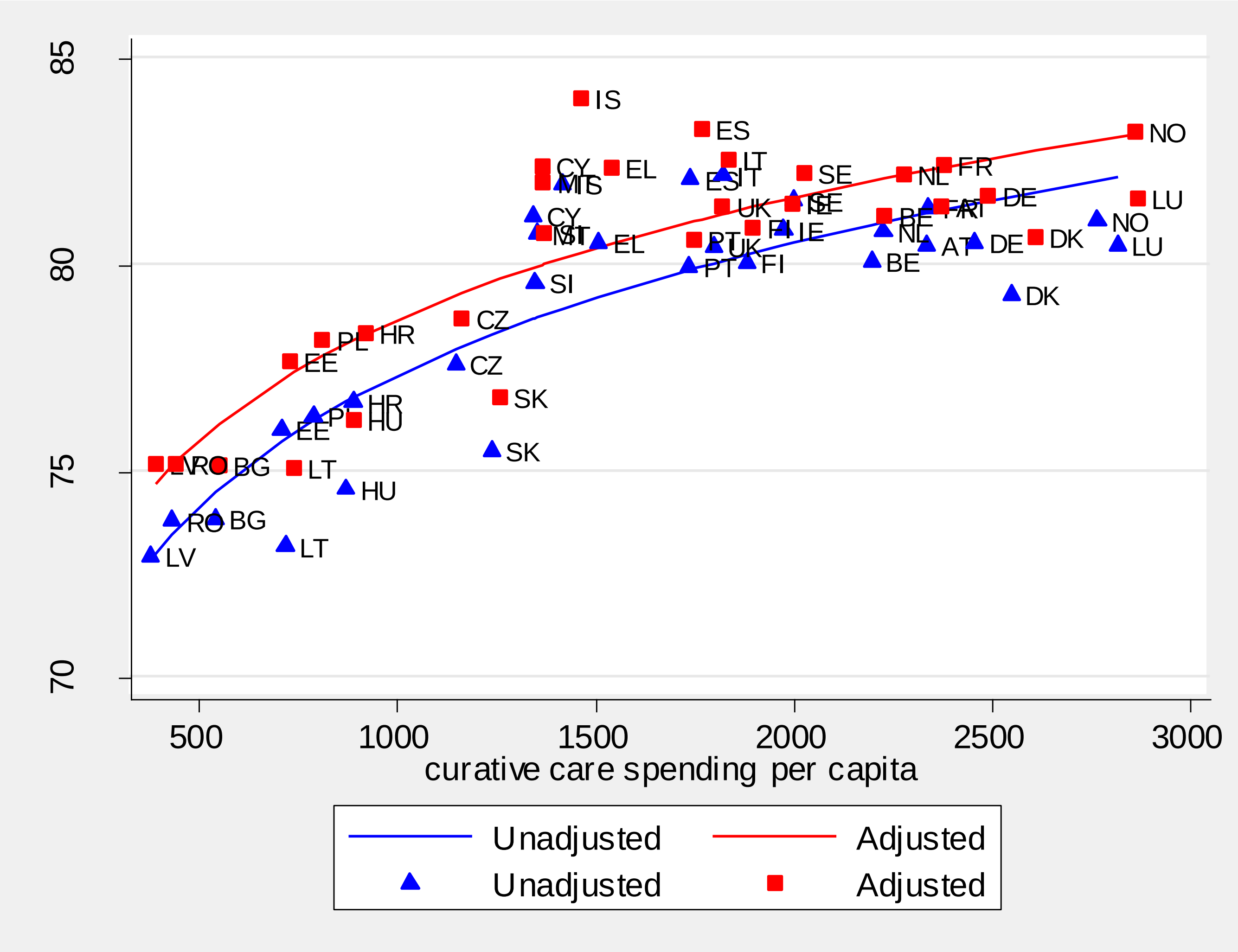

Figure 9.13: The association between curative care spending and life expectancy, unadjusted and adjusted for lifestyle behaviour (scenario 1)