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Health Status Determinants: Lifestyle, Environment, Health Care Resources and Efficiency

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HEALTH STATUS DETERMINANTS: LIFESTYLE, ENVIRONMENT, HEALTH CARE RESOURCES AND EFFICIENCY

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ABSTRACT/RESUME

Health status determinants: lifestyle, environment, health care resources and efficiency

This paper aims to shed light on the contribution of health care and other determinants to the health status of the population and to provide evidence on whether or not health care resources are producing similar value for money across OECD countries. *First*, it discusses the pros and cons of various indicators of the health status, concluding that mortality and longevity indicators have some drawbacks but remain the best available proxies. *Second*, it suggests that changes in health care spending, lifestyle factors (smoking and alcohol consumption as well as diet), education, pollution and income have been important factors behind improvements in health status. *Third*, it derives estimates of countries' relative performance in transforming health care resources into longevity from two different methods – panel data regressions and data envelopment analysis – which give remarkably consistent results. The empirical estimates suggest that potential efficiency gains might be large enough to raise life expectancy at birth by almost three years on average for OECD countries, while a 10% increase in total health spending would increase life expectancy by three to four months.

JEL classification codes: H51; I12; 057; C23

Key words: health status; health care; spending efficiency; public expenditure; panel data regressions; data envelopment analysis

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Déterminants de l'état de santé: style de vie, environnement socio-économique, ressources médicales et efficacité

Ce document examine la contribution des soins médicaux ainsi que d'autres facteurs à l'état de santé de la population et tente de déterminer si les dépenses dans le domaine de la santé produisent les mêmes résultats selon les pays de l'OCDE. En premier lieu, il s'interroge sur les avantages et les inconvénients des différents indicateurs de l'état de santé et en conclut que, malgré leurs défauts, les indicateurs de mortalité et de longévité demeurent les meilleures approximations disponibles. Il suggère ensuite que les évolutions des dépenses de santé, des modes de vie (consommation de tabac et d'alcool, régime alimentaire), du niveau d'éducation, de la pollution et des revenus ont été des facteurs importants de l'amélioration de l'état de santé. Enfin, il estime la capacité relative des différents pays à transformer les ressources médicales en accroissement de la longévité, en s'appuyant sur deux méthodes différentes (régressions sur données de panel et analyse d'enveloppement de données) qui donnent des résultats remarquablement similaires. Les estimations empiriques suggèrent que l'espérance de vie pourrait s'accroitre de presque trois ans en moyenne dans les pays de l'OCDE si les ressources médicales disponibles étaient utilisées plus efficacement, tandis qu'une augmentation des dépenses totales de santé de 10% se traduirait par trois à quatre mois d'espérance de vie supplémentaire.

Code JEL : H51; I12; 057; C23

Mots clé : état de santé ; système médical; efficacité de la dépense; dépense publique; régressions sur données de panel; analyse par enveloppement de données

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HEALTH STATUS DETERMINANTS: LIFESTYLE, ENVIRONMENT, HEALTH CARE RESOURCES AND EFFICIENCY

By Isabelle Joumard, Christophe André, Chantal Nicq and Olivier Chatal[1]

1. Introduction and main findings

1. This paper aims to shed light on the role of medical care in improving the health status of the population and to provide some indicative evidence on whether health care resources are producing the same "value for money" across countries. It forms part of a wider project on public spending efficiency (Box 1).

Box 1. **OECD research into public spending efficiency**

The research presented in this working paper is part of a series of analyses on public spending efficiency. Between 2000 and 2003, an in-depth analysis of public spending reform was carried out for more than 20 countries and a synthesis of the key policy lessons was presented (Joumard *et al.,* 2004). A sectoral approach was later adopted with the objectives of:

- *i)* constructing quantitative indicators to allow cross-country comparisons of public spending efficiency in core domains;
- *ii)* identifying the policy factors most likely to have an influence on efficiency and building relevant policy indicators which would allow cross-country comparisons;
- *iii)* undertaking empirical analysis of the links between the derived policy indicators and public spending efficiency.

The core domains to be given priority are those which account for a large share of public spending and for which solid information on outputs and inputs could be derived from existing OECD databases. On these criteria, primary and lower secondary education was dealt with first, with efficiency indicators and institutional indicators built from a questionnaire (Sutherland *et al.*, 2007 and Gonand *et al.*, 2007). Sutherland and Price (2007) analyse the links between institutional indicators and efficiency outcomes. The Health care is the second sector to be studied since public spending on health amounts to a large share of GDP in most OECD countries, while population ageing combined with technological developments are creating strong upward pressures on future spending. Data limitations are severe for the health care sector, in particular as concerns output or outcome measures (Hakkinen and Joumard, 2007). Priority is thus given to a *system level* approach, as opposed to an approach by disease or by sub-sector (inpatient care, ambulatory care, etc.).

In assessing public spending efficiency, two main features of the health care sector should be noted. *First*, the sector is characterised by a combination of public and private spending (whereas in primary and lower secondary education, public spending clearly dominates) and it is virtually impossible to disentangle the impact of these two components on health outcomes. This makes it difficult to focus on *public spending* efficiency, *per se*, at least in a first stage. *Second*, micro-data do not exist currently in the health care sector as they do for the education sector, where outcome data (PISA results) are available for both schools and pupils. The data sample is thus not wide enough to carry out solid empirical analysis based on the methodology often applied in efficiency analysis, *i.e.* Data Envelopment Analysis (DEA).

1 . This paper is a revised version of a document presented to Working Party No. 1 of the OECD Economic Policy Committee and to the OECD Health Committee during Spring 2008. The authors are indebted to the participants of these meetings, to Robert Price who supervised this work, and also to Elizabeth Docteur, Jorgen Elmeskov, Vincent Koen, Gaëtan Lafortune, Joaquim Oliveira Martins, Howard Oxley, Valérie Paris, Jean-Luc Schneider, Aileen Simkins and other colleagues for their useful comments, and to Veronica Humi and Sandra Raymond for secretarial assistance. The opinions expressed in this paper are those of the authors and are not necessarily shared by the OECD.

2. The main conclusions of the current empirical work can be summarised as follows:

- *Mortality/longevity indicators are imperfect indicators but remain the best available proxies for the population's health status.* Mortality and longevity indicators are numerous, including life expectancy at various ages, premature and infant mortality. Since they are all highly correlated, the choice of a specific indicator within this group should not greatly influence the conclusions when assessing the relationship between health care resources and population health status. Most mortality or longevity indicators, however, suffer from some drawbacks. In particular, some deaths are largely unrelated to the quality of health care interventions (*e.g.* those related to transport accidents). And indicators of health status should ideally reflect the prevalence and severity of sickness and functional disability. Mortality data adjusted for these dimensions are available only sparsely but tend to be highly correlated with raw mortality/longevity data. Other metrics, such as survival rates after specific diagnoses, public satisfaction with the health care system and sick leave, may provide complementary information. Given that they pertain to more narrow, secondary or indirect outcomes, they can, however, hardly serve to draw cross-country comparisons of health care systems' performance.

- *Health care plays an important role in explaining health status changes over time and cross-country differences.* Empirical work suggests that changes in health care spending, lifestyle factors (smoking behaviour, alcohol consumption and diet), education, pollution and income have been important factors behind observed increases in life expectancy and the decline of premature mortality. Educational attainment, income *per capita* and the consumption of fruits and vegetables have increased in most OECD countries since the early 1990s while air pollution, tobacco and alcohol consumption have tended to subside. Meanwhile, *per capita* health care spending surged by more than 50% in real terms between 1991 and 2003 for the OECD area, and panel regressions suggest that this may have contributed to lengthen life expectancy at birth by about 1¼ year.

- *Health care spending is not producing the same value for money across countries*. Two different empirical methods -- panel data regressions and data envelopment analysis (DEA) -- have been used in this paper to derive estimates of countries' relative performance in transforming health care resources into longevity. Each method has its own limitations and results should thus not be taken at face value. However, they deliver a broadly consistent picture, both as regards the size of potential health gains from more efficient spending and country rankings. In many countries, there appears to be substantial scope to improve the health status of the population without increasing spending and other inputs. The empirical estimates presented here suggest that potential efficiency gains might be large enough to raise life expectancy at birth by almost three years on average for OECD countries.

3. The structure of the paper is as follows. The next section assesses the relative merits of existing indicators for population health status and how they relate to one another. The third section identifies the main determinants of the population health status based on a literature review and panel data regressions. The fourth section relies on two main techniques to assess whether health care spending produces the same value for money across countries once due account is taken of other determinants of the population health status.

2. Measuring health care outcomes

4. The first problem to be confronted is to define and measure the gains from health care spending. As noted in Box 1, this paper relies mainly on a *system level* (or aggregated) approach -- as opposed to a disease or sub-sector (in-patient, outpatient, etc.) approach.[2] It also focuses on outcomes -- *i.e.* changes in population health status that can be attributed to the health care sector -- rather than outputs (such as the number of consultations or surgical interventions). Many indicators can potentially be used to proxy the average health status of the population, such as life expectancy (LE), adjusted or not for the health conditions of individuals. None of them, however, provides information on the degree of equity in health status across the population -- an important health care policy objective in many OECD countries. This section reviews a range of indicators that could act as proxies for the health status of the population at the system level, their pros and cons (including data availability) and how they relate one to another.

The average health status of the population can be proxied by various indicators

5. *A priori*, three main groups of system-level indicators could be used as (imperfect) proxies of the average population health status, but each of them has drawbacks:

- *Raw mortality/longevity indicators* (*e.g.* LE at various ages; infant, neonatal and perinatal mortality; premature mortality). These are rather limited indicators of health care outcomes, since they do not account for health condition, quality of life and/or disability.

- *Mortality indicators adjusted for the prevalence of diseases and/or disability and/or for the quality of life*. Time series for these are often lacking and, like raw mortality indicators, adjusted mortality indicators still reflect many factors outside the health care systems (*e.g.* smoking habits).

- *Other health-related indicators.* Sick leave or public satisfaction with the health care system are sometimes presented as additional measures of the performance of health care systems. The lack of consistent data across countries and the predominant role of many factors outside the health care sector affect these indicators even more than those in the two previous groups.

6. These system-level indicators can be compared with disease-level indicators, which come closer to measuring the health gains arising directly from the health care system. These include survival rates after specific treatments. Data coverage across countries and over time remains extremely limited, however.

Raw mortality indicators are partial but widely available

7. Raw mortality indicators have the main advantage of being available over long time periods. For analytical and methodological reasons, nine raw mortality indicators at the system-level have been selected in this paper, out of those available in *OECD Health Data* (Annex 1 provides more information on these indicators as well as on their advantages and limitations):

- *Life expectancy at birth, for females, males and total population*. LE at birth is one of the most widely used summary measures of the population health status at the system level. The gender dimension for this indicator, as well as for others when feasible, has also been retained since

2. For a discussion on the possible approaches to measures health care outcomes and efficiency, see Hakkinen and Joumard (2007).

several empirical studies have concluded that health care systems contribute more to improve the health status for females than males.[3]

- *Life expectancy at 65, for females and males*. LE at older ages provides useful information for at least two reasons. *First*, most of the other health status measures do not cover the older population groups (*e.g.* premature mortality, maternal and perinatal mortality), while recent progress in health status for these groups has been rapid. And dispersion across countries in LE for the elderly is much higher than at birth. *Second*, data available for the public spending component suggest that health care expenditure is often concentrated on older age groups (Figure 1).

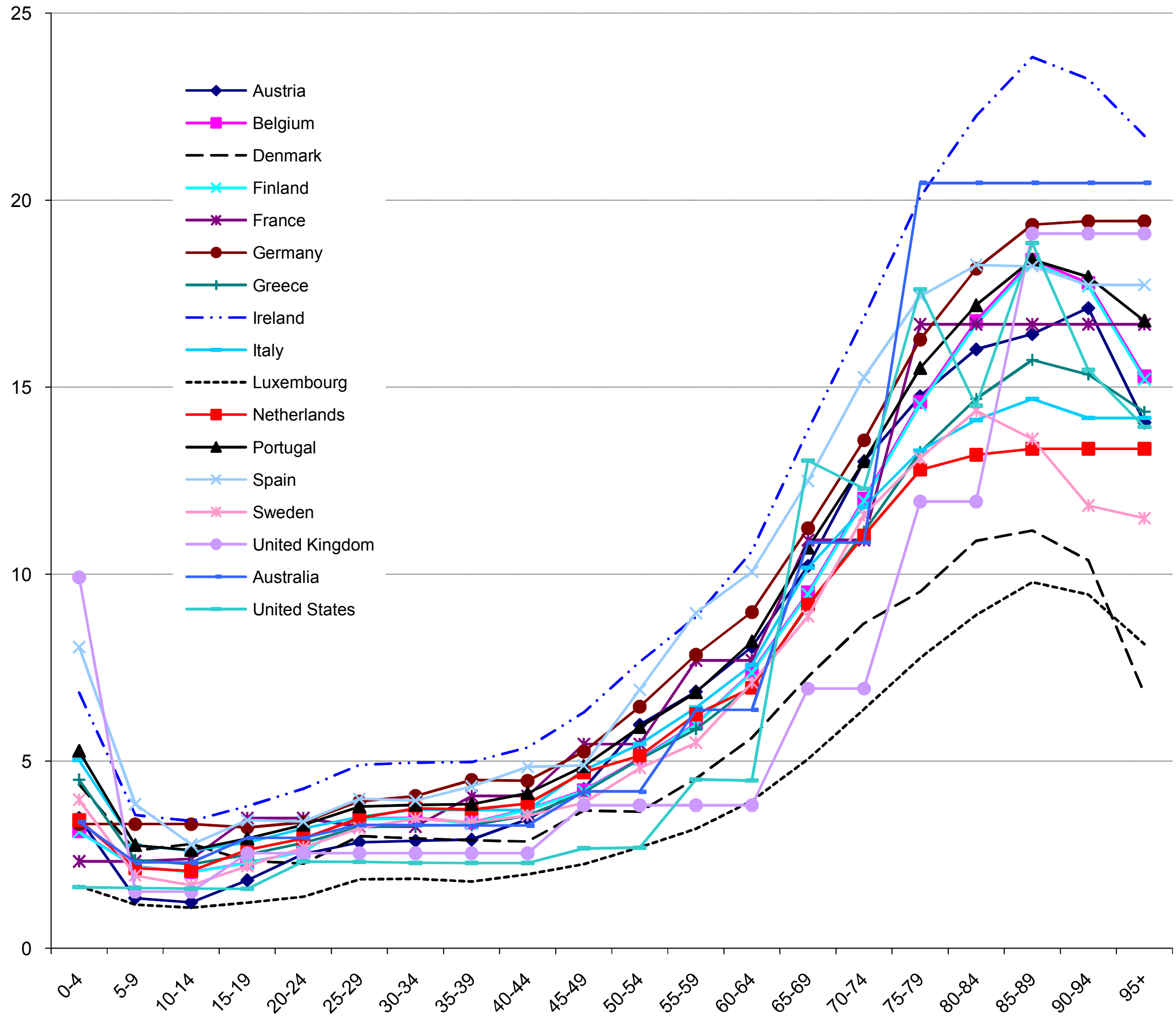
- *Premature mortality, for females, males and total population*. Measured as the number of Potential Years of Life Lost (PYLL), premature mortality has been used in some studies as the main health outcome indicator (*e.g.* Or, 2000a and 2000b). One key advantage is that premature mortality data are available with a breakdown by main causes. Thus, deaths which can be specifically attributed to "external causes" (including land transport accidents, accidental falls, assaults and suicides) can be adjusted for -- a relevant adjustment since premature mortality due to these "external causes" varies significantly across countries, with these causes accounting for less than 12% of total premature mortality in the United Kingdom, compared to above 21% in Finland, Korea, Japan, Luxembourg and the United States (Figure 2). The empirical work carried out here does so with the so-called "adjusted PYLL". The premature mortality indicator has drawbacks for an analysis of the efficiency of health care systems, however. In particular, it does not account for survival after an arbitrary age limit currently set at 70 in *OECD Health Data*, while health care spending often largely concentrates on those above 70.[4]

- *Infant mortality*. This indicator focuses on the health care system's capacity to prevent deaths at the youngest ages, a period of life where health care spending is also relatively high. It has further been argued that infant mortality is more relevant for an efficiency analysis than LE itself, since it is less influenced by factors not related to the health care system such as education or tobacco consumption (Nixon and Ullman, 2006).

3. See Or (2000a and 2000b) and Elola *et al.* (1995).

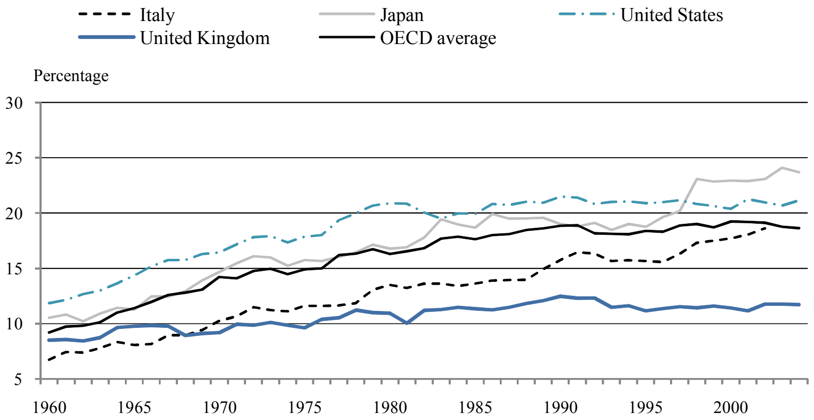
4. See Annex 1 for more details on the definition of PYLL. Eurostat uses another age ceiling of 65 years to measure premature mortality while countries like Australia, Canada and the United States have raised over time the age ceiling to 75.

Figure 1. **Public health care expenditure by age groups** [1]
% of GDP per capita



1. Expenditure per capita in each age group divided by GDP per capita, 1999. Unlike the data used in the rest of the paper, the data shown in this figure do not include expenditure on long-term care.
Source : Oliveira Martins and de la Maisonneuve (2006).

Figure 2. **Premature mortality attributable to "external causes"**[1]



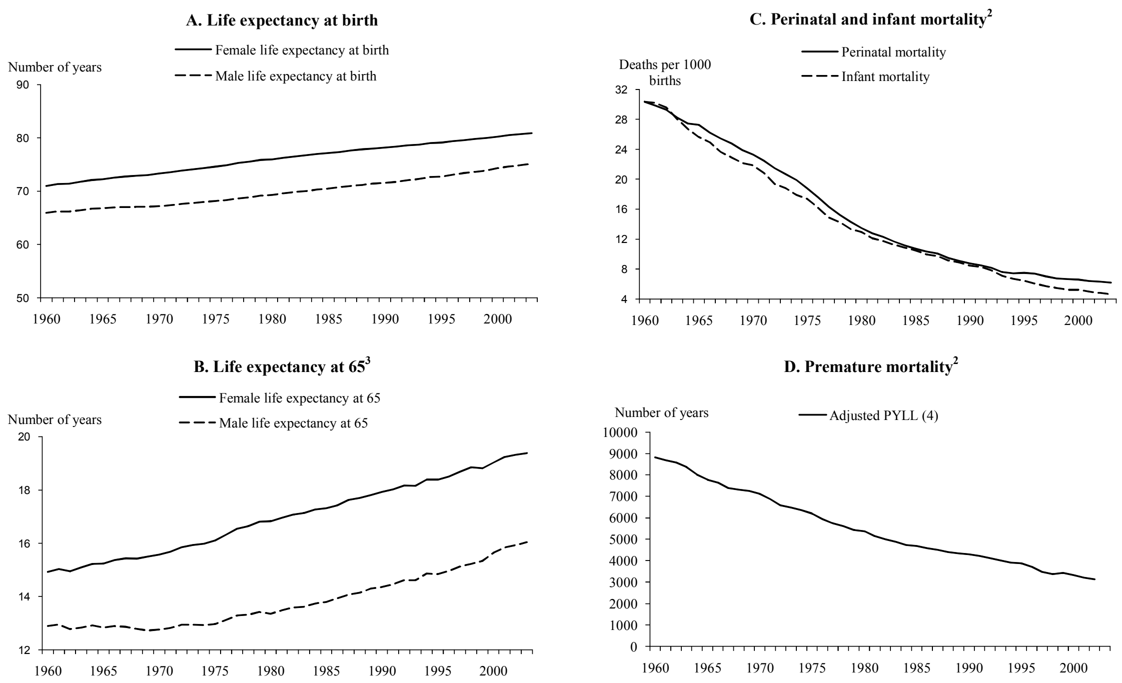
1. Potential years of life lost due to land transport accidents, accidental falls, suicides, assault in per cent of total potential years of life lost.

Source: OECD Health Data 2007.

8. All these indicators deliver broadly consistent messages on recent developments and the relative position of OECD countries. *First*, progress in health status -- as measured by LE, premature mortality or infant mortality -- has been substantial in all OECD countries. LE at birth has increased by almost ten years on average in OECD countries between 1960 and 2005, and infant mortality has been reduced by a factor of seven (Figure 3). *Second*, dispersion across countries has narrowed down substantially for most of these indicators. As an illustration, LE at birth ranged from 71.4 years in Turkey to 82.1 years in Japan for 2005 while in 1960 the range was much higher, with a difference of 25 years between the two extremes (Turkey and Norway).

Figure 3. **Trends in different measures of health outcomes: OECD average**

1960-2003[1]



1. 1960-2002 for panel D.
2. Korea, Mexico and Turkey excluded.
3. Korea and Switzerland excluded.
4. Potential years of life lost excluding deaths which can be attributed to "external causes" (land transport accidents, accidental falls, assaults and suicides).

Source: OECD Health Data 2007.

9. The statistical evidence supports the view that cross-country comparisons of health status are not overly dependent on the choice across raw mortality indicators. Correlation coefficients for these indicators are generally high and significant (Table 1). The ranking of countries varies somewhat across indicators (Table 2, Panel 2), but not dramatically. For example, Japan ranks consistently first or second while Hungary, the Slovak Republic and Turkey are always located at the other extreme of the spectrum. An analysis of Spearman rank correlations confirms that country rankings remain very similar irrespective of the chosen health status measure. To identify homogeneous groups of countries on the basis of the information contained in this wide array of indicators, a cluster analysis has been carried out. It suggests that countries can be classified in three groups (Box 2).

Mortality indicators adjusted for morbidity or disability are better indicators but data are often lacking

10. Efforts have been made by several organisations, notably the World Health Organisation (WHO) and the European Commission, to build health status variables reflecting both mortality and the prevalence of diseases and/or disability (*i.e*. morbidity). *OECD Health Data* contains two such indicators:

- The Health-adjusted Life Expectancy (HALE) aims to summarise the number of years expected to be lived in what might be termed the equivalent of “full health”. Across countries, the correlation between HALE and raw LE indicators is very high and significant.

- The Disability Free Life Expectancy (DFLE) summarises the number of years to be lived without any disability. Because it treats severe and other disabilities equally, this indicator appears less relevant than the HALE, at least for this paper. The difference in coverage may also explain the rather low correlation between the DFLE and raw LE.

The lack of time series data and limited country coverage for these two indicators are, however, the most serious impediment to their use in the empirical work.

Table 1. **Correlations between different measures of health outcomes: common (Pearson) and rank (Spearman) coefficients for 2003**[1, 2]

	Adjusted PYLL[3]			Life expectancy					Perinatal mortality	Infant mortality	Health-adjusted life expectancy[4]					Disability-free life expectancy at birth[5]		Compensated absence from work due to illness[6]
				at birth			at 65				at birth			at 60				
	Total	Female	Male	Total	Female	Male	Female	Male			Total	Female	Male	Female	Male	Female	Male	
Raw mortality indicators																		
Adjusted PYLL, total[3]	1	0.93 **	0.99 **	-0.94 **	-0.88 **	-0.95 **	-0.77 **	-0.85 **	0.50 *	0.84 **	-0.92 **	-0.85 **	-0.94 **	-0.79 **	-0.89 **	-0.50 *	-0.73 **	0.34
Adjusted PYLL, female[3]	0.87 **	1	0.87 **	-0.86 **	-0.86 **	-0.80 **	-0.70 **	-0.71 **	0.53 **	0.84 **	-0.85 **	-0.85 **	-0.81 **	-0.78 **	-0.79 **	-0.56 *	-0.68 **	0.33
Adjusted PYLL, male[3]	0.97 **	0.75 **	1	-0.94 **	-0.85 **	-0.97 **	-0.76 **	-0.87 **	0.47 *	0.80 **	-0.91 **	-0.82 **	-0.95 **	-0.76 **	-0.90 **	-0.44 *	-0.73 **	0.33
Life expectancy at birth, total	-0.89 **	-0.74 **	-0.88 **	1	0.97 **	0.98 **	0.93 **	0.88 **	-0.66 **	-0.71 **	0.97 **	0.93 **	0.96 **	0.92 **	0.93 **	0.50 *	0.69 **	-0.43
Life expectancy at birth, female	-0.83 **	-0.79 **	-0.76 **	0.95 **	1	0.90 **	0.95 **	0.81 **	-0.72 **	-0.78 **	0.96 **	0.97 **	0.91 **	0.95 **	0.86 **	0.51 *	*0.62* *	-0.42
Life expectancy at birth, male	-0.88 **	-0.67 **	-0.91 **	0.97 **	0.87 **	1	0.88 **	0.91 **	-0.57 **	-0.61 **	0.94 **	0.86 **	0.97 **	0.85 **	0.95 **	0.47 *	0.71 **	-0.43
Life expectancy at 65, female	-0.71 **	-0.58 **	-0.68 **	0.91 **	0.94 **	0.85 **	1	0.89 **	-0.55 **	-0.62 **	0.90 **	0.91 **	0.86 **	0.94 **	0.87 **	0.38	0.49 *	-0.44
Life expectancy at 65, male	-0.75 **	-0.59 **	-0.75 **	0.85 **	0.77 **	0.85 **	0.84 **	1	-0.34 *	-0.39 *	0.81 **	0.74 **	0.83 **	0.79 **	0.91 **	0.44 *	0.61 *	-0.52*
Perinatal mortality	0.49 *	0.57 **	0.40 *	-0.48 **	-0.49 **	-0.43 *	-0.39 *	-0.28	1	0.94 **	-0.69 **	-0.74 **	-0.61 **	-0.58 **	-0.43 *	-0.63 **	-0.61 *	-0.32
Infant mortality	0.63 **	0.75 **	0.56 **	-0.67 **	-0.70 **	-0.61 **	-0.54 **	-0.43 *	0.69 **	1	-0.75 **	-0.80 **	-0.67 **	-0.66 **	-0.50 **	-0.31	-0.49 *	0.22
Health and disability adjusted indicators																		
Health-adjusted life expectancy at birth, total	-0.91 **	-0.79 **	-0.87 **	0.94 **	0.94 **	0.89 **	0.88 **	0.73 **	-0.51 **	-0.72 **	1	0.98 **	0.98 **	0.95 **	0.92 **	0.47 *	0.67 **	-0.36
Health-adjusted life expectancy at birth, female	-0.81 **	-0.76 **	-0.74 **	0.90 **	0.95 **	0.81 **	0.88 **	0.68 **	-0.46 **	-0.70 **	0.97 **	1	0.91 **	0.97 **	0.85 **	0.49 *	0.60	-0.34
Health-adjusted life expectancy at birth, male	-0.92 **	-0.72 **	-0.92 **	0.96 **	0.90 **	0.95 **	0.87 **	0.78 **	-0.52 **	-0.67 **	0.97 **	0.91 **	1	0.90 **	0.96 **	0.43	0.69 **	-0.35
Health-adjusted life expectancy at 60, female	-0.77 **	-0.71 **	-0.70 **	0.88 **	0.94 **	0.79 **	0.91 **	0.70 **	-0.39 *	-0.63 **	0.94 **	0.98 **	0.87 **	1	0.89 **	0.37	0.47 *	-0.41
Health-adjusted life expectancy at 60, male	-0.88 **	-0.78 **	-0.83 **	0.96 **	0.93 **	0.91 **	0.90 **	0.84 **	-0.47 **	-0.70 **	0.96 **	0.93 **	0.95 **	0.92 **	1	-0.42	0.62 *	-0.47
Disability-free life expectancy at birth, female	-0.61 *	-0.62 *	-0.56 *	0.57 *	0.47 *	0.47 *	0.38	0.36	-0.61 *	-0.28	0.44 *	0.46 *	0.40	0.37	0.38	1	0.89 **	-0.14
Disability-free life expectancy at birth, male	-0.65 **	-0.53 *	-0.68 **	0.60 *	0.42	0.56 *	0.35	0.35	-0.42	-0.25	0.47 *	0.42	0.48 *	0.34	0.40	0.89 **	1	-0.12
Other indicators																		
Compensated absence from work due to illness	0.30	0.38	0.23	-0.34	-0.30	-0.42	-0.23	-0.45	-0.22	0.01	-0.14	-0.19	-0.04	-0.25	-0.35	-0.11	-0.13	1

Notes:

1. Pearson coefficients, which are shown above the diagonal, measure the linear correlation between the levels of different health status measures across countries in 2003. Spearman coefficients, displayed in the shaded area, measure the correlation between the ranks of the countries ordered according to the relevant variables. Coefficients with ** are significant at less than 1%. Those with * are significant at between 1 and 10%. Those with no * are not significant below a 10% threshold.
2. The number of data used to calculate correlations varies (see below), affecting the degree of significance of estimates.
3. Potential years of life lost (PYLL) are calculated excluding deaths from land transport accidents, accidental falls, suicides and assaults. Data for the PYLL are missing for Belgium, Mexico and Turkey.
4. HALE data are for 2002.
5. Data for the disability-free life expectancy at birth are available only for EU / OECD countries plus Norway.
6. Data for the compensated absence from work due to illness are available only for Austria, Czech Republic, France, Germany, Greece, Hungary, Luxembourg, Netherlands, Slovak Republic, Sweden and United Kingdom.

Source: OECD Health Data 2007.

Table 2. **Measures of health status and country rankings**

2003 or latest year available[1]

Panel A. Levels

	PYLL adjusted, Total			Life expectancy at birth		Life expectancy at 65		Health-adjusted life expectancy (HALE) at birth			Health-adjusted life expectancy (HALE) at 60		Perinatal mortality	Infant mortality	Compensated absence for illness	In-hospital case-fatality for AMI[2]	In-hospital case-fatality for ischemic stroke	In-hospital case-fatality for hemorragic stroke	Breast cancer five-year relative survival rates
	Females	Males	Total	Females	Males	Females	Males	Females	Males	Total	Females	Males							
	per 100 000 persons aged 0-69			Years		Years		Years			Years		per 1000 births		number of days lost/person/year	mortality rates within 30 days after admission			
Australia	2042	3083	2566	82.8	77.8	21.0	17.6	74.3	70.9	72.6	19.5	16.9	3.6	4.8	..	6.4	11.9	24.9	86.6
Austria	2119	3560	2832	81.6	75.9	19.9	16.4	73.5	69.3	71.4	19.3	16.2	6.4	4.5	12.0	12.0	8.0	17.0	..
Belgium	..	..	..	81.7	75.9	19.7	15.8	73.3	68.9	71.1	19.1	15.7	6.8	4.3	..	..	..	..	..
Canada	2306	3302	2804	82.4	77.4	20.8	17.4	74.0	70.1	72.0	19.3	16.1	6.3	5.3	..	9.3	13.1	29.9	86.0
Czech Republic	2520	4937	3705	78.7	72.1	17.3	13.9	70.9	65.9	68.4	16.8	13.5	4.3	3.9	24.9	8.9	12.0	28.4	75.7
Denmark	2823	3876	3352	79.9	75.1	18.6	15.5	71.1	68.6	69.8	17.2	15.2	6.8	4.4	..	6.4	7.2	23.6	85.0
Finland	1897	3912	2907	81.8	75.1	19.6	15.8	73.5	68.7	71.1	18.9	15.7	4.9	3.1	..	11.1	6.3	12.5	88.4
France	2135	4097	3106	82.9	75.9	21.4	17.1	74.7	69.3	72.0	20.3	16.5	10.7	4.0	9.2	7.6	11.2	27.3	79.7
Germany	2169	3772	2974	81.4	75.7	19.6	16.1	74.0	69.6	71.8	19.0	15.9	5.8	4.2	15.6	11.9	10.9	21.0	78.0
Greece	1833	3550	2683	81.3	76.5	18.9	16.8	72.9	69.1	71.0	18.1	16.0	6.6	4.0	5.3	..	..	..	..
Hungary	3912	7917	5808	76.7	68.4	16.9	13.0	68.2	61.5	64.9	15.9	12.2	9.1	7.3	15.6	..	..	..	..
Iceland	1734	2009	1872	82.7	79.7	20.3	18.1	73.6	72.1	72.8	18.7	17.5	2.7	2.4	..	6.4	5.8	30.6	89.4
Ireland	2350	3572	2966	80.7	75.8	18.9	15.7	71.5	68.1	69.8	17.5	14.8	8.5	5.3	..	11.3	11.6	..	79.7
Italy	1951	3248	2592	82.5	76.8	20.7	16.7	74.7	70.7	72.7	19.4	16.4	4.7	3.9	..	9.2	8.5	24.3	85.0
Japan	1618	2697	2154	85.3	78.4	23.0	18.0	77.7	72.3	75.0	21.7	17.5	3.5	3.0	..	10.5	3.3	10.9	83.1
Korea	2096	4287	3187	80.8	73.9	19.0	15.1	70.8	64.8	67.8	17.1	13.2	4.6	5.3	..	18.6	15.2	35.0	84.6
Luxembourg	1917	3759	2852	81.0	75.0	19.0	15.5	73.7	69.3	71.5	19.2	16.0	5.3	4.9	11.1	..	..	..	..
Mexico	..	..	..	77.4	72.4	18.6	17.1	67.6	63.4	65.5	16.3	14.5	19.1	20.5	..	24.5	20.1	32.0	..
Netherlands	2423	3288	2859	80.9	76.2	19.5	15.8	72.6	69.7	71.2	18.4	15.5	7.4	4.8	14.0	8.4	9.2	29.9	83.3
New Zealand	2596	3615	3101	81.7	77.5	20.4	17.5	72.2	69.5	70.8	18.2	16.0	6.7	4.9	..	5.4	11.9	30.9	83.5
Norway	2077	3202	2645	82.0	77.1	20.1	16.7	73.6	70.4	72.0	18.9	16.2	5.1	3.4	..	8.0	8.0	19.0	82.8
Poland	3047	6619	4778	78.8	70.5	17.9	13.9	68.5	63.1	65.8	16.1	12.8	7.5	7.0	..	8.0	11.6	36.9	..
Portugal	2520	4807	3634	80.5	74.2	18.9	15.6	71.7	66.7	69.2	17.7	14.9	5.1	4.1	..	11.8	9.4	26.9	..
Slovak Republic	3307	6798	4979	77.8	69.9	16.9	13.3	69.4	63.0	66.2	16.1	12.3	7.6	7.9	29.2	12.0	12.2	28.5	..
Spain	1939	3807	2867	83.6	76.9	20.7	16.8	75.3	69.9	72.6	19.9	16.4	5.3	3.9	..	10.3	11.5	28.6	..
Sweden	1869	2739	2309	82.5	77.9	20.3	17.0	74.8	71.9	73.3	19.6	17.1	5.2	3.1	26.0	8.3	8.4	18.6	87.0
Switzerland	1901	2930	2413	83.1	78.0	21.0	17.5	75.3	71.1	73.2	20.4	17.1	8.0	4.3	..	8.1	..	..	81.0
Turkey	..	..	..	73.4	68.6	14.9	13.0	62.8	61.2	62.0	14.2	12.8	24.0	28.7	..	..	..	..	..
United Kingdom	2605	4008	3303	80.7	76.2	19.1	16.1	72.1	69.1	70.6	18.1	15.7	7.0	5.3	7.2	11.8	5.5	15.6	80.0
United States	3191	4835	4004	80.1	74.8	19.8	16.8	71.3	67.2	69.3	17.9	15.3	6.9	6.9	..	..	..	..	88.9
Average	2330	4008	3158	80.9	75.2	19.4	16.1	72.3	68.2	70.2	18.3	15.4	7.2	6.0	15.5	10.3	10.1	25.1	83.6
Maximum/Minimum	2.42	3.94	3.10	1.16	1.17	1.54	1.39	1.24	1.18	1.21	1.53	1.43	8.89	11.96	5.51	4.54	6.09	3.39	1.18
Coefficient of variation	0.23	0.33	0.28	0.03	0.04	0.08	0.09	0.04	0.05	0.04	0.09	0.10	0.60	0.89	0.51	0.40	0.35	0.28	0.05

1. PYLL adjusted: 2001 for Denmark and New Zealand; 2002 for Canada, Italy, the Slovak Republic, Sweden, the United Kingdom and the United States. Life expectancy at 65: 2001 for Italy, 2002 for Belgium, Finland, France, Spain and the United Kingdom. HALE at birth and at 65: 2002 for all countries; Perinatal mortality: 2001 for Denmark and Switzerland; 2002 for Finland, Korea, New Zealand and Spain. Infant mortality: 2002 for Korea. In-hospital case-fatality rates for AMI, ischemic or hemorragic stroke: 1999 for Germany, 2003 for Ireland, 2004 for Austria, the Czech Republic, Italy, Korea and Spain, 2003-2004 for the United Kingdom, 2006 for New Zealand and 2005 for all other countries. Breast cancer, five-year relative survival rates: 90-94 for France and Switzerland; 93-96 for Japan; 93-97 for Germany; 94-98 for the Czech Republic; 95-99 for Italy; 96-00 for Iceland and Netherlands; 98-01 for the United kingdom; 98-02 for Australia, Korea, the United States; 98-03 for Canada; New Zealand and Norway; 99-03 for Finland; 99-04 for Ireland and Sweden. 2001-05 for Denmark.

Table 2. **Measures of health status and country rankings (cont.)**

2003 or latest year available[1]

Panel B. Rankings

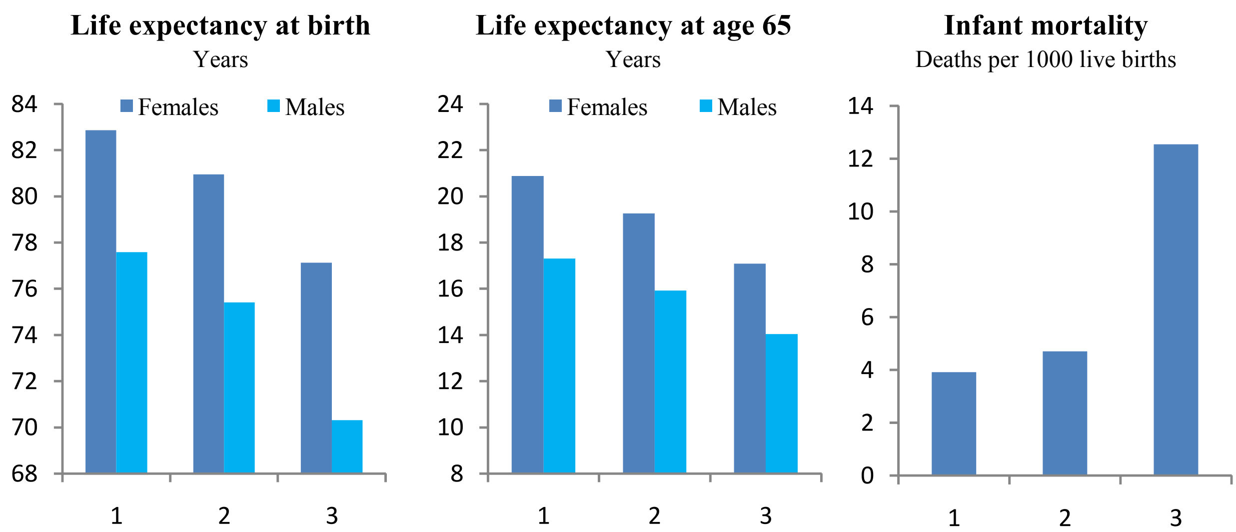
	PYLL adjusted, Total			Life expectancy at birth		Life expectancy at 65		Health-adjusted life expectancy at birth			Health-adjusted life expectancy at 60		Perinatal mortality	Infant mortality	Compensated absence for illness	In-hospital case-fatality for AMI[2]	In-hospital case-fatality for ischemic stroke	In-hospital case-fatality for hemorragic stroke	Breast cancer
	Females	Males	Total	Females	Males	Females	Males	Females	Males	Total	Females	Males							
Australia	10	5	5	5	5	3	3	7	5	6	6	5	3	17	..	2	17	10	5
Austria	13	11	10	14	14	12	15	13	13	13	8	9	15	16	5	21	6	4	..
Belgium	..	..	..	12	14	14	18	15	18	15	11	16	18	13	..	..	..	..	..
Canada	16	9	9	9	7	5	6	8	8	8	8	11	14	21	..	13	21	16	6
Czech Republic	20	24	23	26	26	27	26	24	24	24	25	25	4	6	9	11	19	13	19
Denmark	23	17	21	24	19	24	23	23	20	20	23	21	18	15	..	2	5	8	7
Finland	5	18	14	11	19	15	18	13	19	15	13	16	7	3	..	16	4	2	3
France	14	20	18	4	14	2	7	5	13	8	3	6	28	9	3	5	13	12	16
Germany	15	15	16	15	18	15	16	8	11	11	12	15	13	12	7	20	12	7	18
Greece	3	10	8	16	11	21	10	16	16	17	18	12	16	9	1	..	..	..	..
Hungary	27	27	27	29	30	28	29	28	29	29	29	30	27	27	7	..	..	..	..
Iceland	2	1	1	6	1	9	1	11	2	4	15	1	1	1	..	2	3	18	1
Ireland	17	12	15	20	17	21	21	21	21	20	22	23	26	21	..	17	15	..	16
Italy	9	7	6	7	10	6	13	5	6	5	7	7	6	6	..	12	9	9	7
Japan	1	2	2	1	2	1	2	1	1	1	1	1	2	2	..	15	1	1	12
Korea	12	21	19	19	24	19	25	25	25	25	24	26	5	21	..	23	22	21	9
Luxembourg	7	14	11	17	21	19	23	10	13	12	10	12	11	19	4	..	..	..	..
Mexico	..	..	..	28	25	24	7	29	26	28	26	24	29	29	..	24	23	20	..
Netherlands	18	8	12	18	12	17	18	17	10	14	16	19	22	17	6	10	10	16	11
New Zealand	21	13	17	12	6	8	4	18	12	18	17	12	17	19	..	1	17	19	10
Norway	11	6	7	10	8	11	13	11	7	8	13	9	8	5	..	6	6	6	13
Poland	24	25	25	25	27	26	26	27	27	27	27	27	23	26	..	6	15	22	..
Portugal	19	22	22	22	23	21	22	20	23	23	21	22	8	11	..	18	11	11	..
Slovak Republic	26	26	26	27	28	28	28	26	28	26	27	29	24	28	11	21	20	14	..
Spain	8	16	13	2	9	6	10	2	9	6	4	7	11	6	..	14	14	15	..
Sweden	4	3	3	7	4	9	9	4	3	2	5	3	10	3	10	9	8	5	4
Switzerland	6	4	4	3	3	3	4	2	4	3	2	3	25	13	..	8	..	..	14
Turkey	..	..	..	30	29	30	29	30	30	30	30	27	30	30	..	..	..	..	..
United Kingdom	22	19	20	20	12	18	16	19	16	19	18	16	21	21	2	18	2	3	15
United States	25	23	24	23	22	13	10	22	22	22	20	20	20	25	..	..	..	..	2

1. PYLL adjusted: 2001 for Denmark and New Zealand; 2002 for Canada, Italy, the Slovak Republic, Sweden, the United Kingdom and the United States. Life expectancy at 65: 2001 for Italy, 2002 for Belgium, Finland, France, Spain and the United Kingdom. HALE at birth and at 65: 2002 for all countries; Perinatal mortality: 2001 for Denmark and Switzerland; 2002 for Finland, Korea, New Zealand and Spain. Infant mortality: 2002 for Korea. In-hospital case-fatality rates for AMI, ischemic or hemorragic stroke: 1999 for Germany, 2003 for Ireland, 2004 for Austria, the Czech Republic, Italy, Korea and Spain, 2003-2004 for the United Kingdom, 2006 for New Zealand and 2005 for all other countries. Breast cancer, five-year relative survival rates: 90-94 for France and Switzerland; 93-96 for Japan; 93-97 for Germany; 94-98 for the Czech Republic; 95-99 for Italy; 96-00 for Iceland and Netherlands; 98-01 for the United kingdom; 98-02 for Australia, Korea, the United States; 98-03 for Canada; New Zealand and Norway; 99-03 for Finland; 99-04 for Ireland and Sweden. 2001-05 for Denmark.
2. AMI: Acute Myocardial Infarction.

Box 2. **Grouping of countries according to population health status**

Cluster analysis has been used to summarise the information available on different dimensions of the population health status in 2003 and identify homogeneous groups of countries. To derive groups, it relies on a hierarchical and agglomerative (bottom-up) classification. The algorithm begins with each country as a separate cluster and successively groups countries into larger clusters, so as to minimise the within-cluster variance (Ward's Minimum-Variance Method). A tree diagram showing successive clusters provides information on the loss of information resulting from each aggregation, allowing the partition of the sample into groups of countries which share common characteristics on the variables included in the analysis (LE at birth and at age 65 for males and females and infant mortality). Three country groups clearly emerge:

Group 1	**Group 2**	**Group 3**
Australia	Austria	Czech Republic
Canada	Belgium	Hungary
France	Denmark	Mexico
Iceland	Finland	Poland
Italy	Germany	Slovak Republic
Japan	Greece	Turkey
New Zealand	Ireland	
Norway	Korea	
Spain	Luxembourg	
Sweden	Netherlands	
Switzerland	Portugal	
	United Kingdom	
	United States	



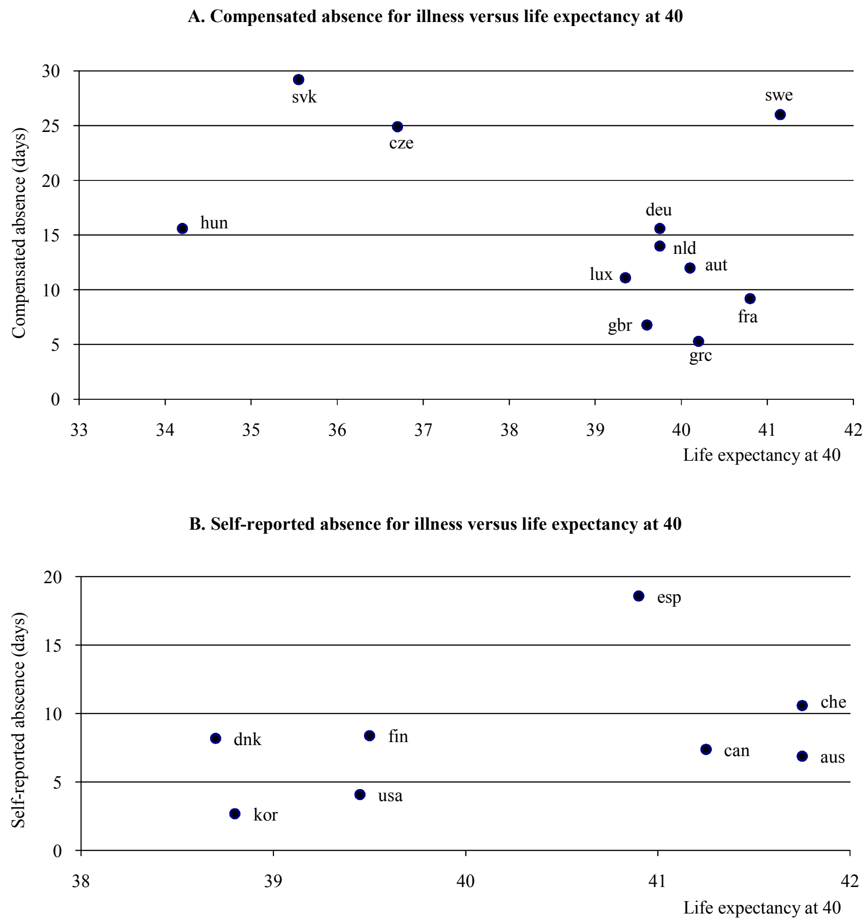
Source : *OECD Health Data 2007* and OECD calculations.

Sick leave and public satisfaction cannot be used for cross-country comparisons

11. The amount of sick leave taken could in principle be considered as a potentially important policy performance indicator. By preventing people from becoming sick or by curing them rapidly, health care can be expected to reduce the amount and length of sick leave, boosting the labour supply and thus the economy's potential output. By helping to keep sick people alive for longer, health care may, however, also increase sick leave. Previous studies have further suggested that sick leave largely reflects macroeconomic developments and various aspects of the institutional framework (including generosity of sickness benefits, type of job contracts and strictness of employment protection legislation).[5] The overall impact of health care on sick leave may thus be ambiguous. The sparse data available reveal that, across countries, compensated sick leave is poorly correlated with "conventional" health status measures (Figure 4). Hence, sick leave cannot be used as a reasonable proxy for cross-country comparisons of health care outcomes.

Figure 4. **Sick leave is poorly correlated with conventional health status measures**

2003[1]



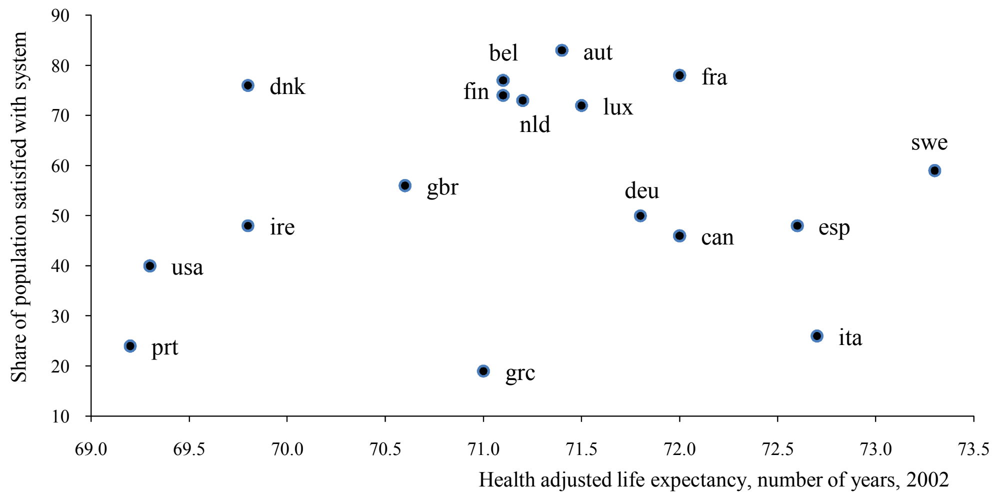
1. Number of days: 2002 for Greece and Switzerland, 2004 for Australia, 2005 for Korea. Life expectancy: 2002 for Finland, Spain and the United Kingdom.

Source: OECD Health Data 2007.

5. See Osterkamp and Röhn (2007) for international comparisons, Grignon and Renaud (2007) for France and Askildsen *et al.* (2000, 2002) for Norway.

12. Public satisfaction with the health care system could also be a criterion for assessing its performance. Satisfaction is, however, affected not only by people's experiences with the health system but also by their expectations, which are likely to vary significantly across countries and over time. As a matter of fact, public satisfaction appears to be poorly correlated with HALE across OECD countries (Figure 5). Even within countries, Adang and Born (2007) show that changes in health care system performance are not associated with changes in public satisfaction.[6]

Figure 5**. Public satisfaction and health adjusted life expectancy**



Source : OECD Health Data 2007 (Public's satisfaction with health care system, seventeen countries, 1999-2000).

Disease-specific survival rates could provide some information on the gains from the health system

13. Disease-based survival or fatality rates can provide interesting information, since health care systems can significantly improve the prognosis of some rather common diseases.[7] Among the relevant indicators built in the context of the OECD Health Care Quality Indicator (HCQI) project, four have been selected for analysis here: breast cancer, in-hospital case-fatality rates for Acute Myocardial Infarction (AMI), as well as for hemorrhagic and ischaemic strokes (see the Annex 1 for more details).

14. Benchmarking countries on the basis of their health system performance in treating specific diseases remains challenging. Differences both in the time periods that are covered and in country practices may be important issues.[8] In addition, some countries may perform well with respect to one disease but not

6. At a certain point in time people might well be dissatisfied, but if the level of aspiration adjusts downward, satisfaction may well increase while health care performance remains constant or even declines.

7. A disease-based approach was used in the 2003 OECD monograph which examines the treatments, costs and outcomes of diseases that particularly afflict the elderly.

8. As most countries do not have unique patient identifiers and the ability to track patients after hospital discharge, in-hospital case-fatality rates are based on hospital admissions and restricted to mortality within

for others. Even restricting the analysis to the hospital sector, the choice of an indicator matters for cross-country comparisons. In particular, there is only a very poor cross-country correlation between in-hospital case-fatality rates for hemorrhagic strokes and for AMI for similar time periods (Annex 3). At a country level, Japan for instance has the best scores for in-hospital case-fatality rates for both ischemic and hemorrhagic strokes, and this is consistent with the extremely good rankings when using system-level mortality indicators such as HALE. Japan, however, ranks only fifteenth if countries are benchmarked on the basis of hospital performance with respect to AMI.

Information on equity in population health status is critically missing

15. Investigation of health system performance should extend to equity aspects, which are often considered as a key policy objective. Equity can be defined in different terms -- most notably equity in access or equity in health status across policy-relevant dimensions of the population (*e.g.* geographical areas, income groups, racial or ethnic groups). Information on health status by income or socio-economic status is, however, critically missing in *OECD Health Data*. A study carried out in 2003 for the OECD on equity in access to health care for 21 countries in the year 2000 revealed significant inequity favouring the better off in about half of the countries: the degree of inequity in doctor use was highest in the United States, followed by Mexico, Finland, Portugal and Sweden.[9]

3. Determinants of health status: literature review, model specification and empirical results

Most previous analyses have adopted a production-function approach …

16. The health status of a population can be seen as determined by a combination of health care resources, lifestyle and socio-economic factors. This "production-function approach" has been adopted frequently in the literature to assess the role of several factors on LE or other health status variables, both over time for specific countries and/or across countries or sub-national governments -- *e.g.* states in the United States, Canadian provinces and Brazilian municipalities (Annex 2 provides a snapshot of existing empirical work).

…with broad consensus on the inputs potentially contributing to population health status

17. A rather wide consensus on the main factors (inputs) shaping the population health status emerges from previous analyses. These include:

- *Health care resources per capita*. Most empirical work has included some health care resource variable, though specifications differ greatly. Health care resources can be measured in monetary terms (health care spending) or in physical terms (number of doctors in most cases, with capital goods such as the number of hospital beds and scanners accounted for in a few studies). Some studies restrict the analysis to the share of health care spending financed by the public sector (as opposed to total spending). A few others focus on specific health spending components, in particular pharmaceuticals (*e.g.* Miller and Frech, 2002; Shaw *et al.,* 2002).

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the hospital. Thus differences in practices in discharging and transferring patients may influence the findings.

9. Horizontal equity is defined as the extent to which adults in equal need of physician care appear to have equal rates of medical care utilisation. See van Doorslaer *et al*. (2004) for more details. Information on within-country regional disparities in age-adjusted mortality rates and in the density of practising physicians, nurses and hospitals beds, for the year 2004, is provided in the 2007 edition of *OECD Regions at a glance*.

- *A vector of lifestyle factors*. Empirical analyses have usually included the consumption of tobacco and alcohol, as well as some proxy for diet (consumption of fat, sugar, calories, or fruits and vegetables, or several of these).

- *A vector of socio-economic factors*. Income *per capita*, education and pollution are the socio-economic factors most frequently included in empirical work. Other factors such as poverty, urbanisation, income distribution, unemployment, ethnic origin and/or religion, and occupational status, are also included in a few studies.

18. Institutional features have been considered as inputs to health status in very few empirical studies. Some researchers have introduced time-invariant dummies; others have selected specific aspects with time series data often derived from *OECD Health at a Glance*.[10] Including health care institutions into the health production function, however, raises methodological and conceptual issues. *First*, data on institutions are seldom available, in particular over time. In this context, the empirical analysis has to be carried out on a cross-country or cross sub-national government basis and often on a very small number of observations. Empirical results may thus lack robustness. *Second*, the dummy approach may not be satisfactory -- for instance there are no pure integrated health service systems, nor pure social security systems. *Third*, choosing one individual institutional feature may be questionable since there is no firm consensus on the features that matter most for health spending effectiveness. Interaction effects across institutions may also play an important role. For all these reasons, institutional features have not been included at this stage in the estimated production function.[11]

Specification and empirical results

19. The econometric work presented in this paper extends earlier studies by using the latest data from *OECD Health Data*, by introducing new variables to control for lifestyle and socio-economic factors, and by testing various specifications. The health production function has been specified as follows:

$$\mathrm{Y}_{it} = \alpha_i + \beta \cdot HCR_{it} + \gamma \cdot SMOK_{it} + \phi \cdot DRINK_{it} + \theta \cdot DIET_{it} + \delta \cdot AIRPOL_{it} + \sigma \cdot EDU_{it} + \lambda \cdot GDP_{it} + \varepsilon_{it}$$

with all variables in log form and Y_{it} being a measure of the population health status as discussed earlier (in country *i*, at period *t*), *i.e.* alternatively:

- LE at birth, for males and females,
- LE at 65, for males and females,
- Premature mortality (adjusted for the "external causes"), for males and females,
- Infant mortality.

and inputs consisting of:

HCR = health care resources *per capita*, either measured in monetary terms (total spending including long-term care at GDP PPP exchange rates and constant prices) or in physical terms (*e.g.* health practitioners).

SMOK = tobacco consumption in grams *per capita*.

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10. Examples include: insurance *versus* integrated national system (Elola *et al*., 1995), insurance coverage of the population (Nixon and Ullman, 2006), share of public spending (Berger and Messer, 2002).

11. In a second stage of the work, institutional indicators will be built and a study will be carried out to understand how individual features relate in practice with one another. After this study, an analysis of the possible relations between institutions and spending effectiveness is envisaged in a third stage of the project (see Box 1 for further details).

DRINK	=	alcohol consumption in litres *per capita*.
DIET	=	consumption of fruits and vegetables *per capita* in kgs.
AIRPOL	=	emissions of nitrogen oxide (NOx) *per capita* in kgs.
EDU	=	share of the population (aged 25 to 64) with at least upper secondary education.
GDP	=	GDP *per capita*.

20. Panel data regression results suggest that health care resources, lifestyle and socio-economic factors are all important determinants of the population health status (Box 3 presents the main features of panel data regressions). Virtually all regression coefficients for these inputs are highly significant, statistically, and carry the expected sign,[12] with health care resources measured either in physical or monetary terms (Tables 3 and 4). The choice of health status indicator (LE at birth, at older age, premature mortality, etc.) is not crucial to the analysis, as foreseen above.

Box 3. **Panel data regression: key features, drawbacks and consistency checks**

Regressions on a panel of 23 OECD countries over the period 1981-2003 have been used to assess the impact of health care resources on the health status of the population.[a] This approach allows both changes over time in each country and differences across countries to be taken into account. Socio-economic and lifestyle factors affecting the population's health status, such as income and education, diet, pollution and consumption of alcohol and tobacco are controlled for.

Panel data regression results should be interpreted with care since they may be affected by specification and data problems. This box describes the specification choices and the range of consistency checks which have been performed.

Endogeneity and collinearity across exogenous variables

An important difficulty in estimating the health production function is that two of its major determinants, GDP *per capita* and health care spending *per capita* are highly correlated. Furthermore, health spending could also be affected by the health status of the population. Both collinear and endogenous variables may lead to biased coefficient estimates. In theory, the endogeneity problem could be addressed using instrumental variables. However, in practice, results prove too sensitive to the choice of instruments to provide reliable estimates. A way to assess the sensitivity of coefficient estimates to the inclusion of correlated regressors is to estimate alternative specifications excluding alternatively some regressors (see Annex 3). Specifications excluding GDP *per capita* imply a larger impact of health spending, suggesting that when GDP is omitted, the spending variable also captures income effects that are unrelated to health expenditure. The same phenomenon occurs when the education variable is omitted. Still, health spending is statistically significant in all specifications. Controlling for income *per capita* and the level of education reduces the risk of an upward bias on the health spending coefficient. Replacing GDP *per capita* by the share of service employment taken as a proxy for working conditions also yields results close to those of the equation with GDP *per capita.* Coefficients for pollution and lifestyle variables are fairly stable across specifications, indicating no collinearity problem associated with these variables.

Shape of the production function

Both dependent and explanatory variables are in logarithms and regression coefficients can thus be interpreted as elasticities. Alternative specifications have been tested: first, with all the variables in level terms, and second with only the dependent variable in levels and the explanatory variables in logarithms. Results were not materially different.

Time dimension

The onset of a disease is often related to factors beginning years earlier. As an illustration, smoking causes

12. The only variable which does not always carry the expected sign is diet. When premature mortality is the dependent variable, the coefficient for the consumption of fruit and vegetable is positive, though not highly significant.

cardiovascular disease with relatively short lags and lung cancer with much longer lags and nutrition decades ago could be having its full effect only today. The empirical analysis carried out in this paper does not include lagged input variables; contemporaneous lifestyles are taken as proxies for earlier habits. This rather heroic assumption was adopted because time series for lifestyle variables, but also for education and pollution, are relatively short, precluding the introduction of relevant lagged effects. This may lead to underestimate the impact of lifestyle factors. Replacing contemporaneous GDP *per capita* by the same variable lagged 15 years, assuming that an individual's health condition is affected by economic conditions prevailing at earlier stages of its life in particular during infancy, yields a significant coefficient and does not alter other coefficients materially.

Autocorrelation and heteroskedasticity

Residuals from equations estimated by Ordinary Least Squares are both heteroskedastic and serially correlated. Therefore, the equations have been estimated by Generalised Least Squares (GLS), with correction for heteroskedasticity and first order autocorrelation (with a specific autoregressive coefficient for each country). In this context, the R^2 statistic is irrelevant.

Country fixed-effects

In addition to the level of the exogenous variables described above, countries differ according to a number of characteristics which may also affect the health status of their population. Institutional features of their health system may play an important role. Failing to account for these country specificities would lead to biased estimates of the model coefficients. The introduction of country fixed-effects allows taking into account cross-country heterogeneity not reflected in other explanatory variables.

a. Due to the lack of data, seven OECD countries were excluded from the regression analysis and for some of the 23 countries the estimation period is shorter. After 2003, data are lacking for many countries, e.g. on tobacco consumption (see Annex 1 for details).

Table 3. **Health status determinants, with health care resources measured by practitioners**[1, 2]

Econometric results for the main scenario

Dependent variables[3] / Explanatory Variables[3]	Life expectancy at birth			Life expectancy at 65		Premature mortality (adjusted)			Infant mortality
	Female	Male	Total	Female	Male	Female	Male	Total	
Constant	3.940***	3.650***	3.800***	2.090***	1.570***	11.600**	12.000***	12.000***	10.600***
Practitioners	0.013***	0.017***	0.015***	0.032**	0.043***	-0.089**	-0.062	-0.072*	-0.440***
Smoking	-0.007***	-0.018***	-0.014***	-0.028***	-0.070***	0.060**	0.190***	0.150***	0.072
Alcohol	-0.011***	-0.018***	-0.015***	-0.024*	-0.010	0.290***	0.040	0.130**	0.370***
Diet	0.003	0.004	0.004	0.002	0.008	0.088**	0.030	0.055*	0.120*
Pollution	-0.003	-0.012***	-0.006**	-0.032***	-0.058***	0.150***	0.170***	0.160***	0.190***
Education	0.040***	0.045***	0.042***	0.056***	0.046***	-0.250***	-0.300***	-0.260***	-0.500***
GDP	0.035***	0.066***	0.051***	0.099***	0.170***	-0.480***	-0.480***	-0.510***	-0.870***
Number of observations	254	254	254	254	254	236	237	236	254
Number of countries	22	22	22	22	22	21	21	21	22

Notes:

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
   *** indicates significance at 1%; ** indicates at 5% and * indicates significance at 10%.
2. Practitioners are calculated as the number of practising physicians and half the numbers of practising nurses.
3. Details on individual variables are provided in Annex 1.

Source: OECD calculations.

Table 4. **Health status determinants, with health care resources measured by spending**[1]

Econometric results for the main scenario

Dependent variables[2] / Explanatory variables[2]	Life expectancy at birth			Life expectancy at 65		Premature mortality (adjusted)			Infant mortality
	Female	Male	Total	Female	Male	Female	Male	Total	
Constant	4.009***	3.641***	3.825***	2.178***	1.638***	11.172***	12.871***	12.244***	8.516***
Spending	0.035***	0.045***	0.041***	0.051***	0.061***	-0.272***	-0.300***	-0.282***	-0.572***
Smoking	-0.000	-0.006**	-0.004	-0.019***	-0.057***	0.063***	0.088***	0.077***	0.077*
Alcohol	-0.011***	-0.014***	-0.011***	-0.017	-0.004	0.234***	0.082*	0.115***	0.327***
Diet	0.003	0.004	0.004	0.013*	0.028***	0.044*	0.001	0.014	0.044
Pollution	-0.009***	-0.018***	-0.012***	-0.037***	-0.068***	0.169***	0.153***	0.162***	0.320***
Education	0.029***	0.031***	0.030***	0.064***	0.045***	-0.107**	-0.227***	-0.182***	-0.378***
GDP	0.006	0.035***	0.019***	0.044***	0.107***	-0.285***	-0.292***	-0.292***	-0.379***
Number of observations	325	325	325	325	325	307	307	307	325
Number of countries	23	23	23	23	23	22	22	22	23

Notes:

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity. *** indicates significance at 1%; ** indicates at 5% and * indicates significance at 10%.
2. Details on individual variables are provided in Annex 1.

Source: OECD calculations.

21. Panel regression results provide estimates of the impact of the factors identified above on health status proxies, both over time and across countries. Life expectancy at birth has increased by two-and-half and three-and-half years for females and males, respectively, on average in the OECD area since the early 1990s. Over the same period, all of the health determinants have moved favourably -- the consumption of tobacco and alcohol has declined; air pollution has been curtailed; educational achievement and income *per capita* have increased steadily and health care resources *per capita* have been raised dramatically. Econometric results suggest that a gain in life expectancy at birth of slightly more than one year for both females and males could be attributed to the increase in health care spending *per capita* (Table 5). Differences in spending would also seem to be the single most important factor explaining differences in health status across countries, though other factors also play important roles (Table 6).

Table 5. **Contributions of main explanatory variables to changes in health status**

1991-2003

	Gains in life expectancy				Decline in infant mortality rate	*Memorandum item:* 1991-2003 changes
	At birth		At 65			
	Female	Male	Female	Male		
Explained by[1]:	*Years*				*Deaths/1000 live births*	*Per cent*
Health care spending	1.14	1.34	0.38	0.37	- 2.53	51.7
Smoking	0.00	0.12	0.09	0.21	- 0.21	- 22.6
Alcohol	0.06	0.07	0.02	0.00	- 0.24	- 6.7
Diet	0.02	0.02	0.02	0.03	0.03	7.4
Pollution	0.15	0.29	0.15	0.22	- 0.75	- 19.7
Education	0.50	0.49	0.26	0.14	- 0.89	24.8
GDP	0.11	0.63	0.20	0.39	- 1.01	28.5
Memorandum item:						
Observed changes	2.49	3.45	1.40	1.63	- 4.67	

1. Contributions of health status determinants are calculated using coefficients estimated by the model (panel data regressions on a sample of countries for which data were available). Observed changes in health status are calculated for the OECD area. The sum of identified contributions may thus differ from the actual change in health status measures.

Source: OECD calculations.

Table 6. **Contributions of main explanatory variables to cross-country differences in life expectancy at birth**

Differences between countries and the OECD average for each variable expressed in years, 2003

	Life expectancy at birth	Determinants							
		Spending	Education	Tobacco	Alcohol	Diet	Pollution	GDP	Country-specific effect[1]
Australia	2.2	0.7	-0.3	0.1	-0.1	0.0	-0.9	0.2	2.5
Austria	0.8	1.0	0.2	0.0	-0.2	0.0	0.1	0.3	-0.7
Belgium	0.8	0.8	-0.3	0.0	-0.2	0.0	0.1	0.2	0.2
Canada	1.8	0.9	0.4	0.1	0.1	0.0	-0.8	0.3	0.9
Czech Republic	-2.7	-1.8	0.5	-0.1	-0.3	-0.1	0.0	-0.6	-0.3
Denmark	-0.5	0.7	0.3	0.0	-0.2	0.0	-0.2	0.3	-1.5
Finland	0.5	-0.2	0.1	0.2	0.0	-0.1	-0.3	0.2	0.5
France	1.3	0.9	-0.2	0.0	-0.3	0.0	0.4	0.2	0.4
Germany	0.6	0.8	0.4	-0.1	-0.1	0.0	0.5	0.1	-1.0
Greece	0.9	0.3	-0.7	-0.2	0.0	0.2	0.0	0.0	1.3
Hungary	-5.6	-2.0	0.1	0.0	-0.3	0.0	0.5	-0.8	-3.1
Iceland	3.1	1.1	-0.2	0.0	0.3	-0.1	-1.0	0.3	2.6
Ireland	0.3	0.3	-0.3	0.0	-0.4	0.0	0.1	0.4	0.2
Korea	-0.6	-2.4	0.1	0.0	0.0	0.1	0.3	-0.4	1.7
Netherlands	0.6	0.6	-0.2	-0.1	-0.1	0.0	0.3	0.3	-0.3
New Zealand	1.5	-0.6	0.2	0.1	0.0	0.0	-0.5	-0.1	2.3
Norway	1.5	1.8	0.5	0.1	0.3	0.0	-0.3	0.7	-1.5
Poland	-3.4	-3.5	0.3	0.0	0.1	-0.1	0.4	-1.1	0.5
Sweden	2.1	0.6	0.3	0.0	0.2	0.0	0.3	0.2	0.5
Switzerland	2.5	1.5	0.4	-0.1	-0.2	0.0	0.9	0.3	-0.4
Turkey	-7.4	-4.5	-2.3	-0.1	1.5	0.1	0.7	-1.9	-1.0
United Kingdom	0.5	-0.1	0.4	0.1	-0.2	0.0	0.1	0.2	0.0
United States	-0.5	2.9	0.5	0.0	0.0	0.0	-0.6	0.6	-4.0
Memorandum items:									
Maximum range	10.5	7.4	2.8	0.4	1.8	0.3	1.8	2.5	6.6
Estimated coefficients		0.041	0.030	-0.004	-0.011	0.004	-0.012	0.019	

1. The country-specific effect is calculated as the sum of the country fixed-effect plus the residual of the equation.

Source: OECD calculations.

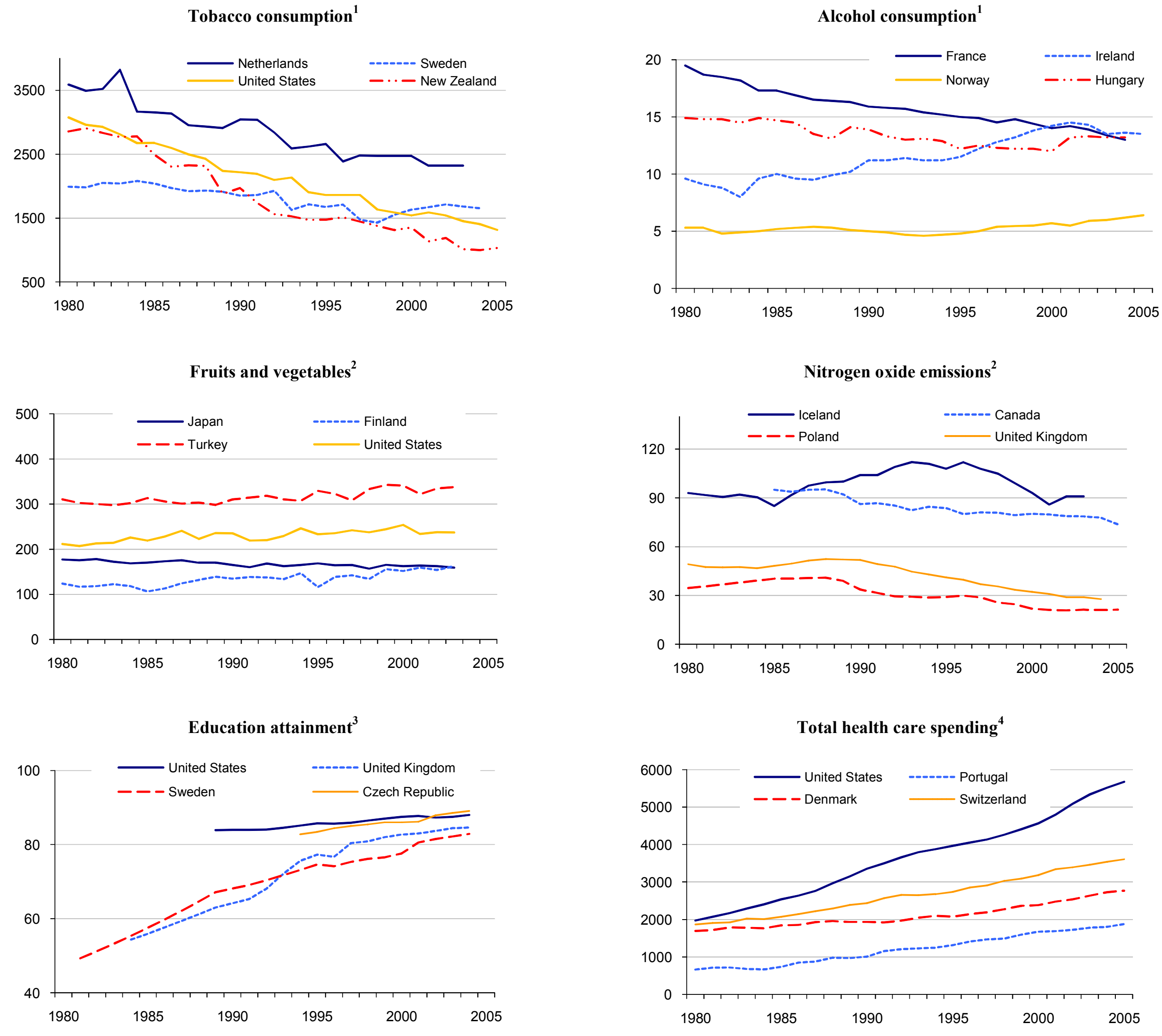
22. The remainder of this section briefly justifies the selection of inputs as well as their measurement, and provides a more detailed description and discussion of the empirical results.

Lifestyle factors: tobacco, alcohol and diet

23. Excessive alcohol consumption has numerous harmful health effects.[13] In particular, it increases the risk for heart stroke and vascular diseases, as well as liver cirrhosis and certain cancers. Alcohol consumption has fallen in many OECD countries since the early 1980s but some countries are standing out -- consumption has increased sharply in Ireland and has remained broadly stable in Nordic countries (Figure 6). The empirical results suggest that differences in alcohol consumption can help to explain a gap in LE at birth of up to 1.8 years between low-consumption countries (such as Turkey) and high-consumption ones (including France, Hungary and Ireland).

13. Although a moderate consumption of alcohol may, according to some studies, have beneficial impacts on health, high consumption is detrimental.

Figure 6. **Trends in health status determinants - selected OECD countries**



1. Grams or litres per capita for people aged 15 and over.
2. Kilos per capita.
3. Per cent of population aged 25-64 years with at least upper secondary educational level (i.e. up to ISCED categories 3-4).
4. Total expenditure on health per capita expressed in 2000 US dollars and PPP.
Source: OECD Health Data 2007.

24. Tobacco is the second major cause of death in the world and is directly responsible for about one in ten adult deaths worldwide according to the 2002 World Health Report. Influenced by public awareness campaigns, smoking prohibition in public areas and in the workplace, advertising bans and increased taxation, tobacco consumption has declined steadily in most OECD countries since the early 1980s, in particular in the United States, Canada and New Zealand where consumption has more than halved. However, disparities in tobacco consumption across countries remain large, with heavy smoking in the Czech Republic, Greece, Japan, the Netherlands and Turkey. The empirical results are consistent with tobacco being a major determinant of the population health status, in spite of measurement problems for tobacco consumption and the impossibility to account for time lags through which tobacco consumption impacts on health. (see Annex 1 for more details on the measure of tobacco consumption). A gender

dimension further emerges: both the coefficient and significance of tobacco consumption are higher for males than females.[14]

25. A healthy diet is widely recognised as a major factor in the promotion and maintenance of good health. Diets can be proxied by several variables and, in this empirical work, the consumption of fruits and vegetables has been given preference (see Annex 1). Low intake of fruits and vegetables is estimated by the WHO to be one of the main risk behaviours in developed countries and, in particular, to cause about 31% of the occurrence of ischaemic heart disease, 11% of strokes and 19% of gastrointestinal cancers (*World Health Report*, 2002). The consumption of fruits and vegetables has tended to increase over the past two decades in most OECD countries (Japan and Switzerland being the main exceptions). However, cross-country differences remain very high -- Mediterranean countries and Korea being best placed while Eastern European countries, Japan and most Nordic countries are located at the other extreme. The empirical work undertaken here finds a limited impact of the consumption of fruits and vegetables on LE in some specifications. But its impact on premature and infant mortality is often insignificant or even goes in the wrong direction. The difficulty of accounting for time lags could partly explain the rather weak results for the impact of diet on health status.

Socio-economic factors: pollution, education and income

26. The impact of water, soil, noise and air pollution on health is increasingly recognised (OECD, 2008b). Partly reflecting limited data availability, *per capita* emissions of nitrogen oxide (NOx) have been used as a proxy for pollution in the current empirical work. By contributing to the formation of fine particulate matter pollution, NOx emissions aggravate respiratory illness and cause premature death in the elderly and infants. They also play a major role in the formation of ground-level ozone (smog) pollution.[15] On high ozone days, there is a marked increase in hospital admissions and visits for asthma and other respiratory illnesses. Since the early 1990s, however, NOx emissions *per capita* have declined in many OECD countries, partly reflecting technological improvements of combustion processes, in particular in power production and vehicle engines, and government plans aimed at reducing NOx emissions (*e.g.* Canada, European Union). The empirical work suggests that this has contributed to improve the population health status -- the relation between air pollution, as defined by NOx emissions, and health status is consistently negative and rather robust to changes in model specifications.[16]

27. Although the strong relation between health and education is well established, the direction of causality is still debated and may well be both ways. Better health is associated with higher educational investment, since healthier individuals are able to devote more time and energy to learning. Because they live longer, they also have a greater incentive to learn since they have a higher return on human capital. On the other hand, education causes health if better-educated people use health care services more effectively

14. Estimates are quite stable when changing the measure of health care resources (*e.g.* total spending *versus* number of physicians and nurses). Changing the measure of tobacco consumption to the share of daily smokers also produces similar results: a 10% cut in the share of adult population smoking daily would result in a 1½ to 2½ per cent decline in premature mortality. These estimates are broadly in line with previous studies (see for instance Berger and Messer, 2002; Crémieux *et al.*, 1999 and Or, 2000a). When a gender-specific tobacco variable is introduced (share of smoking persons), the coefficient for females becomes highly significant but remains lower than for males, probably reflecting that females tend to smoke less heavily than males.

15. Smog is formed when NOx and volatile organic compounds combine in the presence of heat and sunlight.

16. Country-specific effects of NOx emissions should be interpreted with caution due to their transborder impact, *e.g.* smog being transported by the wind from one country to another. Iceland is a particular case in point, as the rather substantial NOx emissions from its fishing fleet do not directly affect Icelanders themselves.

-- they tend to comply better with medical treatments, use more recent drugs and better understand discharge instructions.[17] Education, as measured by the share of population aged 25 to 64 with an upper-secondary degree or higher, has been increasing steadily in particular in most of the countries with the lowest levels in the early 1980s (*e.g.* Belgium, Greece and Spain; Mexico, Portugal and Turkey being notable exceptions to this catch-up process). The current empirical work suggests that education contributes significantly to health, over and above its impact on lifestyle factors, and explains a large part of cross-country differences in health status.

28. The level of income is even more correlated with the population health status across OECD countries than education. Higher GDP *per capita* affects health by facilitating access to many of the goods and services which contribute to improving health and longevity (*e.g.* food, housing, transportation), over and above those specifically accounted for by the model (in particular education and health care resources). The relation between GDP *per capita* and health may also reflect working conditions -- richer countries tend to have a higher share of service activities, which are considered to be less health-damaging than others such as construction or industrial activities. As with education, the direction of causality has been debated, some arguing that the relation mainly runs from health to income. This may be particularly true at the micro level (Cutler *et al.*, 2005; Kiuila and Mieszkowski, 2007): healthy people have more time and resources to study and work; they tend to be more productive and earn more. At the macro level, however, the causality likely runs predominantly from income to health, at least in developed countries. The regression results are consistent with *per capita* income being a major determinant of the population health status. These results are not altered when replacing *per capita* income by the share of service employment to address causality issues (between *per capita* income and health spending) and to account for the fact that higher GDP acts on health mainly *via* better working conditions in the larger service sector.

29. Many other factors are widely believed to have an impact on health status but data paucity has made it impossible to include them into the model. Income dispersion could be considered as a determinant of the health status of a country's population as suggested by several studies.[18] This view, however, has been challenged in other research.[19] While time series are not available, Gini coefficients are available for a few points in time and cross-country correlations between various health status measures and these Gini coefficients are weak. Working conditions and safety standards are also likely to affect health but the lack of internationally comparable data and the complexity of the links between work conditions and health status make it impossible to assess the impact.[20] Broadly similar considerations would apply to physical activity and obesity which likely have a significant impact on health status.

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17. Education may also affect health through lifestyle factors, as better educated people tend to adopt healthier lifestyles (*e.g.* smoke less, exercise more, etc.). Since lifestyle factors are controlled for separately in the equation, they should not be the explanation for the impact of education on health in the model. Useful references on the relations between health and education include: Becker (2007), Cutler *et al.* (2005), Cutler and Lleras-Muney (2006), Feinstein *et al.* (2006) and Grossman (2004).

18. See for instance Wilkinson (1992), Mac Isaac and Wilkinson (1997), De Vogli *et al.* (2005). Income inequality would impact health through three main channels: *i)* socio-economic factors: housing and working conditions, education, nutrition, pollution, insecurity; *ii)* psychosocial factors: direct impact of psychological stress on health and risky behaviours, in particular excessive consumption of alcohol, tobacco and bad eating habits; *iii)* inequalities in access to health care. There is some evidence that even health systems proposing universal coverage have not fully succeeded in eliminating social differences in access to health care (Cambois and Jusot, 2007).

19. See for instance Gravelle (1998), Judge (1995), Lorgelly and Lindley (2007) and Mackenbach (2002).

20 . Dorman (2000) estimated that the costs of occupational illnesses and injuries (including curative treatment but also lost production and insurance coverage) amounted to approximately 3% of GDP in the United States in 1992 and to several points of GDP in a number of European countries in the 1990s. Incidence

Health care resources

30. While recent empirical studies invariably conclude that socio-economic and lifestyle factors are important determinants of the population health status, the contribution of health care resources has been much debated. Berger and Messer (2002) as well as Or (2000a and 2000b) conclude that health care resources have played a positive and large role up to the early 1990s for a panel of OECD countries. And Crémieux *et al*. (1999) and Soares (2007) reach similar conclusions for Canadian provinces and Brazilian municipalities, respectively. Hitiris and Posnet (1992) and Nixon and Ulmann (2006) both find that an increase in health expenditure *per capita* has an impact on health status, which is statistically significant but quite small. Likewise, Thornton (2002) concludes for the United States that additional medical care utilisation is relatively ineffective in lowering mortality and increasing life expectancy, and thus that health care policy which focuses primarily on the provision of medical services and ignores larger economic and social considerations may do little to benefit the nation's health. Finally, Filmer and Pritchett (1997) as well as Self and Grabowski (2003) find that health care resources have no significant impact on the population health status.[21]

31. Controversy about the link between health care resources and health status could reflect measurement problems and/or the fact that health-care resources represent too broad a concept, with some components having a more marked impact on health status than others. Special attention has been given to these issues in this study, which tests alternative specifications with different measures of health care resources.

Measuring health care resources in physical terms

32. Health care resources have first been measured in physical terms, paying special attention to the availability of physicians, nurses, hospital beds and technical equipment. Many previous empirical analyses have focused on the number of physicians as a proxy for health care resources.[22] However, this rather restrictive approach is potentially misleading. In particular, nurses also play an important role in providing health care. Furthermore, the ratio of the number of nurses to that of physicians varies widely across OECD countries, partly reflecting differences in the demarcation of roles between the two categories. As an illustration, Poland, Finland, the United States, Australia and Ireland all had about 2½ practising physicians per 1000 inhabitants in 2003. The number of nurses ranged from 4.7 in Poland to 14.8 in Ireland (Figure 7, Panel A).

33. This argues for including both the number of nurses and the number of physicians into the regressions. Since the numbers of nurses and physicians are highly correlated over time – for many countries, the ratio of nurses to doctors hardly changes (Figure 7, Panel B) -- introducing them separately would lead to unreliable results. Therefore, a human resource indicator has been constructed which accounts for the number of both nurses and physicians: half the number of nurses is added to the number of

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rates of occupational illnesses and injuries have been reduced significantly since then but costs are likely to have remained quite significant. According to the US Bureau of Labor Statistics, fatal occupational injuries declined from 5.3 to 4.0 per 100000 between 1992 and 2006, while nonfatal injuries and illnesses dropped from 8.9% to 4.4% over the same period. The role of new work patterns in the evolution of work-related mental illness is assessed in OECD (2008a). Teng *et al*. (1995) assess the cost-effectiveness of various life-saving interventions, from safety regulations to various health care activities.

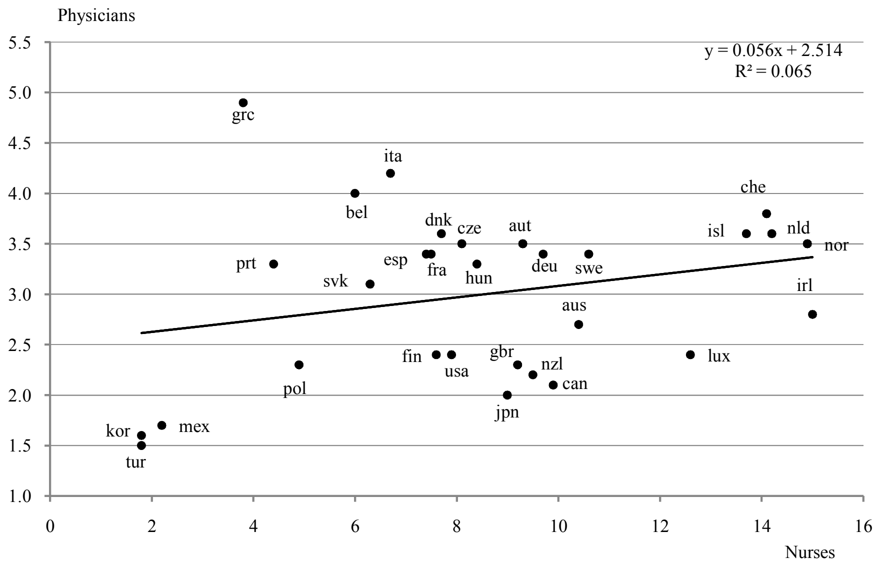
21. It should be noted that Filmer and Pritchett (1997) and Self and Grabowski (2003) use public health spending instead of total spending and rely on a cross-section analysis.

22. See for instance Crémieux *et al.* (1999), Or (2000b) and Retzlaff-Roberts *et al.* (2004).

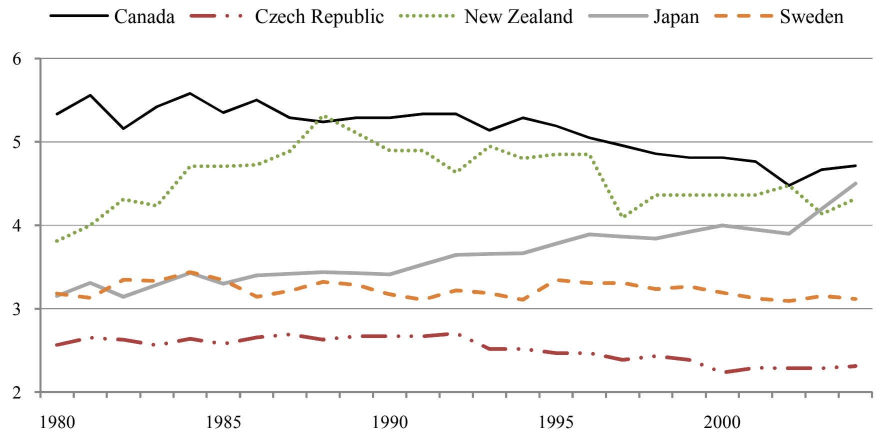
physicians. The lower weight for nurses is applied on an *ad hoc* basis but also reflects the fact that nurses often work on a part-time basis and are assumed to have a lower productivity (as suggested by relative salaries). Regression results for this specification suggest that the number of health practitioners plays a role in health performance: estimated elasticities of most health status measures with respect to the human resource indicator are highly significant. They indicate that a 10% increase in the number of health practitioners would increase LE at birth by around two months on average in OECD countries.[23]

Figure 7. **Number of physicians and nurses across countries and over time**

A. Cross-country comparisons: number per 1000 inhabitants, 2004[1]



B. Changes in the ratio of nurses to physicians over time



1. 2002 for nurses in the United States.
Source: OECD Health Data 2007.

23. Health status for men tends to be slightly more responsive to health care resources than for women. This result is at odds with some previous studies suggesting that male health status is much less sensitive to health care resources. This difference could reflect the fact that the analysis adjusts premature mortality data to exclude non-health related mortality causes which are more frequent causes of mortality for males than females (see above). In Or (2000a), the elasticity of (non-adjusted) premature mortality to the number of physicians was more than four times smaller for men than women.

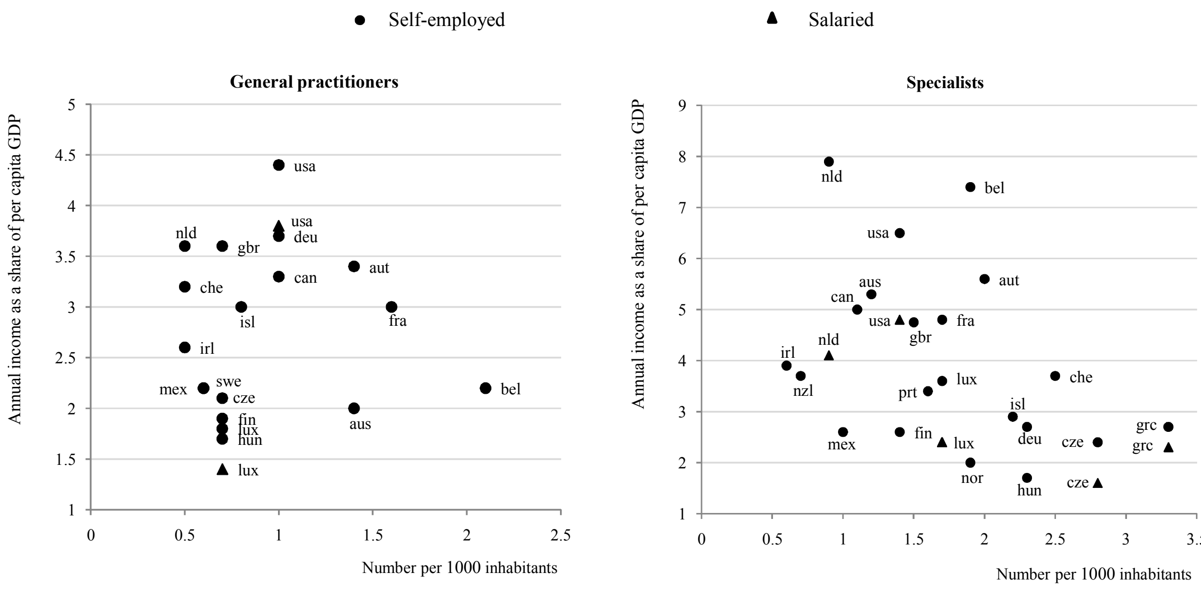
34. The role of health capital equipment in shaping health status has also been given special consideration. Cross-country variations in the number of hospital beds and scanners are even higher than in the number of doctors and nurses. When included in the regressions, the number of hospital beds was in most cases not significant or had the wrong sign (implying that a decline in the number of hospital beds improves health status). The ambiguous impact of hospital beds could be related to the development of high-tech health procedures, contributing to shorten the average length of stays. Over the estimation period, the number of hospital beds has declined in many OECD countries, while LE and the overall efficiency of health care resources have been increasing. It may also corroborate some findings that show that hospitalisation for conditions that do not require surgery increases with the supply of staffed hospital beds.[24] The number of scanners is never significant and proxies for health care capital equipment have not been included in the regressions.

Measuring health care resources in monetary terms

35. Health care resources can also be measured in monetary terms, so as to capture aspects not covered by physical inputs. In particular, health practitioners' remuneration is likely to impact on productivity. In practice, the level of physicians' compensation varies greatly across countries and partial evidence suggests that the greater the number of specialists the less they are paid (Figure 8). The preferred specification thus includes total health care spending, at constant prices and PPP exchange rates instead of health care resources measured in physical terms. The regression results, which are rather robust across model specifications, suggest that a 10% increase in total health spending would increase LE at birth by between 0.3 and 0.5%, *i.e.* by three to four months, on average in the OECD area.[25]

Figure 8. **Density and compensation levels of physicians**

2003 or latest year available



Note: In Finland the number of specialists only includes those in the public sector.
Source: OECD Health Data 2007.

24. Peterson and Burton (2007) provide some references.

25. Life expectancy at birth in the OECD area stood at 78.6 years in 2005. The results are broadly in line with those presented by Or (2000a) -- a spending elasticity of 0.18 for female premature mortality (compared with 0.27 in the current baseline regression)-- and Crémieux *et al.* (1999).

36. Some categories of spending may contribute more to improve the population health status than others. In one of the specifications tested, spending on health care has been broken down into three components: pharmaceuticals, inpatient and outpatient care. It is, however, difficult to isolate their respective impacts since they are highly correlated both across countries and over time.[26]

37. In contrast with some previous studies, spending has not been broken down by paying agents (public and private) for two reasons.[27] First, in many countries, a single health care intervention may be paid simultaneously by public subsidies, private insurance and out-of-pocket payments. In these circumstances, it would be extremely difficult to disentangle how public *versus* private spending influences the health status. Second, comparisons across countries and over time could be blurred by tax expenditures, which are not consistently reported but which can be large when identified. In some countries, including the United States, they amount to more than 1% of GDP (see Annex 1).

4. Health care resources are not producing the same "value for money" across countries

38. Several reasons call for caution in interpreting the results on the response of the population health status to an increase in health care spending presented so far. These include:

- Elasticity estimates are averages for the population. The increase in spending may not raise LE for the great majority but could raise the LE of a few by several years.

- As for most economic activities, health care could be subject to declining returns. Hence, it might prove costly for countries with high health status to improve further.

- Health care spending over the past decade has partly focused on improving the quality of life, *e.g.* to mitigate pain for sick people, for example with the development of palliative care units.[28] Using mortality data to measuring the impact of health care spending may underestimate the benefits (*e.g.* those related from lower morbidity and/or disability, and better quality of life).

- "How money is spent" is probably as important as "how much is spent" and countries may be quite different in this respect, with great variety in institutional arrangements.

The rest of this section focuses on the last aspect, proposing two alternative approaches to assessing whether health care resources produce the same value for money across countries when due account is taken of differences in lifestyles, income and other health status determinants. It also assesses the degree of consistency of these alternative approaches as well as their limitations.

26. Countries with high levels of spending on outpatient care also tend to spend more than average on pharmaceuticals. And over time, the ratio between outpatient and pharmaceutical spending is rather stable for individual countries. Including the three spending components simultaneously into the regression model yields very unstable results, while focusing instead on a specific component is likely to create an upward bias – the selected component may capture the effect of omitted components. Miller and Frech (2002), and Shaw *et al.* (2002) have carried out panel data regressions to study the impact of pharmaceutical spending on the population health status.

27. Several studies incorporate the share of public versus private funding in total health care financing, including Filmer and Pritchett (1997), Or (2000a) and Self and Grabowski (2003).

28. Fogel (2004) argues that the health care system contributes to reduce morbidity (hip replacement, cataract surgery and so on) but not much to reduce mortality.

Panel data regressions provide some indication of the relative performance of individual countries

39. Performance in transforming health care resources into health status may vary across countries. Panel data regressions can shed light on this relative performance if it is assumed that unexplained differences in health status indicators across countries reflect efficiency differences in the use of existing inputs. This approach is similar to the one frequently used in growth accounting, where the total factor productivity is derived as the residual of an aggregate production function. The implicit assumption here is that all the unexplained country-specific effects and residuals reflect inefficiency, and not measurement errors, omitted variables and other factors. [29] Supporting this assumption are the very low correlations, if any, between the unexplained differences in health status indicators and recent values of key variables which could not be included in the panel regressions – in particular, income dispersion (as measured by Gini coefficients), obesity and population density.[30] In that context, the relative performance of individual countries has been proxied by focusing on the model country-specific effects and residuals, controlling for environmental factors and the amount of inputs. As previously, health care resources have been measured, alternatively, by total spending or by the indicator for the number of health practitioners.

40. Figure 9 displays for each country the residual difference between the actual level of LE at birth and the level accounted for by the model. When measuring health care resources by spending, LE at birth is more than two years above the level predicted by the model for Iceland, Australia and New Zealand (Figure 9, Panel A). A broadly similar pattern emerges when measuring health care resources by the number of health care practitioners (Figure 9, Panel B). Some countries, however, seem to perform slightly worse when health care resources are measured in monetary terms, including Austria, Germany, Switzerland and Turkey. Apart from spurious influences, differences in results between the two measures could be related to differences in compensation systems and levels for health practitioners and/or to the impact of other health spending components, such as medical equipment or drugs (both through volume and price effects).[31]

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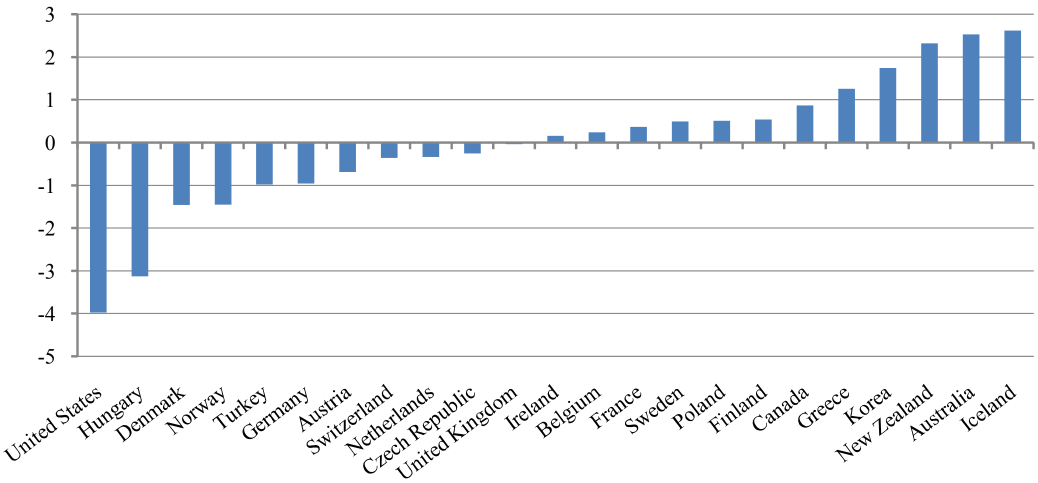
29. Hence, the approach adopted in this paper only provides an upper limit of possible efficiency improvements in each country. Some authors have used a Stochastic Frontier Analysis which aims at disentangling statistical noises from inefficiency components (Jacobs *et al.*, 2006). Such an approach has not been implemented in this paper because the sample was too small to obtain meaningful results.

30 . Health and safety regulations, work and housing conditions and poverty could also play a role but the lack of data constrains the inclusion of these variables in the analysis.

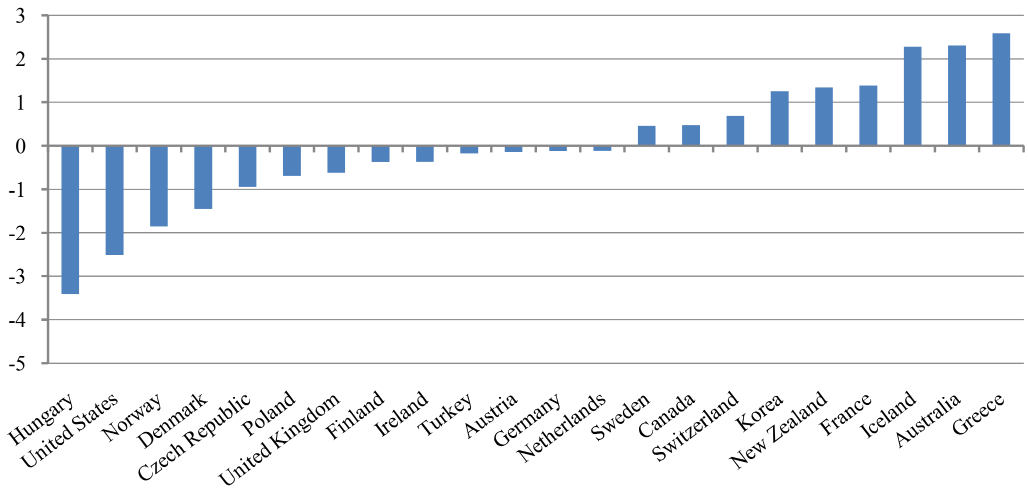
31. Roughly similar country rankings are obtained for life expectancy at age 65 (Annex 3), with Spearman rank correlation coefficients exceeding 0.8. Country rankings differ more when focusing on infant mortality, with correlation coefficients ranging between 0.3 and 0.7.

Figure 9. **Panel regressions: years of life which are not explained by the general model**[1]
2003

A. With health care resources measured in monetary terms



B. With health care resources measured by the number of health practitioners



1. Model residuals and country fixed-effects deviations from averages are added and considered as a proxy for relative efficiency (i.e. the years shown in the above figure can be viewed as years of life that would be saved (or lost) if country i was as efficient as the OECD average).
A Spearman rank correlation of .76 indicates a strong correlation in the ranking obtained through the two panel regressions.
Source: OECD calculations.

Panel data results and DEA efficiency scores are broadly consistent

41. Efficiency measures can be derived from a DEA (Data Envelopment Analysis) and compared with those stemming from the econometric results from panel data. As was the case for the work on public spending efficiency in the primary and lower secondary education sector (Sutherland *et al.*, 2007), the DEA method can be used to derive two types of efficiency scores (Box 4). Input-oriented scores measure

Box 4. **DEA: Methodological aspects**

Data envelopment analysis constructs an efficiency frontier and derives efficiency scores for entities involved in a similar production process. An efficient entity is defined as one that cannot improve output without increasing inputs (output-oriented DEA) or cannot reduce inputs without compromising output (input-oriented DEA). By assumption, the frontier linking efficient entities defines best practice and potential efficiency gains for less efficient units are measured by their position relative to the frontier (or envelope). Efficiency scores can be computed with an orientation either on output (measuring the possible improvement in output for a given level of inputs) or inputs (measuring the possible reduction in inputs for a given output). A graphic illustration with one output (LE at birth) and one input (health care spending *per capita*) is given in Figure 10. This paper mainly focuses on output-oriented DEA, assessing the improvement in LE which could be achieved by a country using the same quantity of health care resources in a similar socio-economic and lifestyle environment, but being as efficient as the best performers.

Selection of inputs

The health status of the population has many determinants but, given the size of the sample, the number of inputs and outputs needs to be limited in order to obtain reliable DEA estimates. In this study, one output -- LE at birth of the total population -- and three inputs are included. The inputs represent the three main dimensions of health outcome production: health resources (measured by health spending or the number of health practitioners), socio-economic environment (measured by the PISA index of Economic, Social and Cultural Status, hereafter ESCS) and lifestyle (measured by *per capita* consumption of fruits and vegetables). The ESCS index is originally centred on zero, and since DEA only allows positive variables, it had to be transformed as described in Sutherland *et al.* (2007). For all the variables, a greater level of inputs leads to higher output. Inputs having a negative impact on output, such as smoking, alcohol consumption or pollution have been avoided since there is no consensus in the literature on the appropriate protocol to apply to this kind of input (Dyson *et al*., 2001). Since DEA results can be rather sensitive to the set of inputs selected, results of an alternative analysis where the ESCS index is replaced by GDP *per capita* is shown in Figure A4.4.

Returns to scale

The shape of the DEA efficiency frontier depends on the assumptions about returns to scale. In the production of health, returns to scale are taken as decreasing beyond a certain level.

Correcting for bias and creating confidence intervals

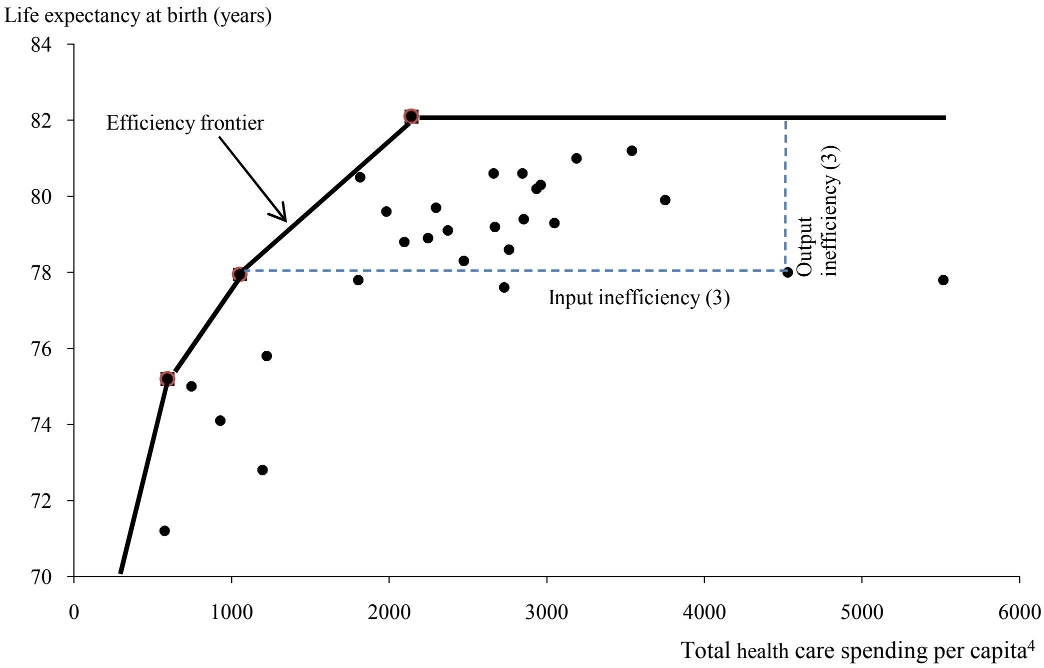
Since the frontier is defined by efficient countries, efficiency scores tend to be biased upwards by possible omissions. In this paper, the bias has been corrected through "bootstrapping", which is a statistical method for estimating the sampling distribution of an estimator. In addition, the bootstrap provides confidence intervals for the efficiency scores. Computing confidence intervals around DEA scores is important since estimates are sensitive to measurement errors, statistical noise and outliers. However, it should be kept in mind that the reliability of an efficiency score depends on the density of observations in the region of the frontier where a country is located. Countries with atypical levels of inputs and outputs tend to be considered as efficient but this result is merely a consequence of the lack of comparable observations (Simar and Wilson, 2005).

the extent to which inputs could be scaled back while holding constant the actual level of health status.[32] Output-oriented scores assess how much the health status could be improved while holding inputs constant (Figure 10). Because the output-oriented approach is conceptually closer to the production function approach used in panel data regressions, it has been given preference.

32. In Annex 3, tentative input-oriented DEA results are provided.

Figure 10. **DEA: the efficiency frontier and the measurement of inefficiency - an illustration**[1]

Scenario with one output and one input[2], 2004 or latest year available



1. The "efficiency frontier" has been designed under the assumption of non-increasing returns to scale.
2. The main scenario accounts for three inputs (health care spending, ESCS, consumption of fruits and vegetables) and one output (life expectancy at birth).
3. Potential efficiency gains are derived by measuring the distance from the efficiency frontier as a ratio of the distance from the axis to the efficiency frontier. They can be defined as the amount by which input could be reduced while holding constant the level of output (input inefficiency) or as the amount by which output could be increased while holding constant the level of input (output inefficiency).
4. Expressed in 2000 US dollars and PPP.
Source: OECD Health Data 2007.

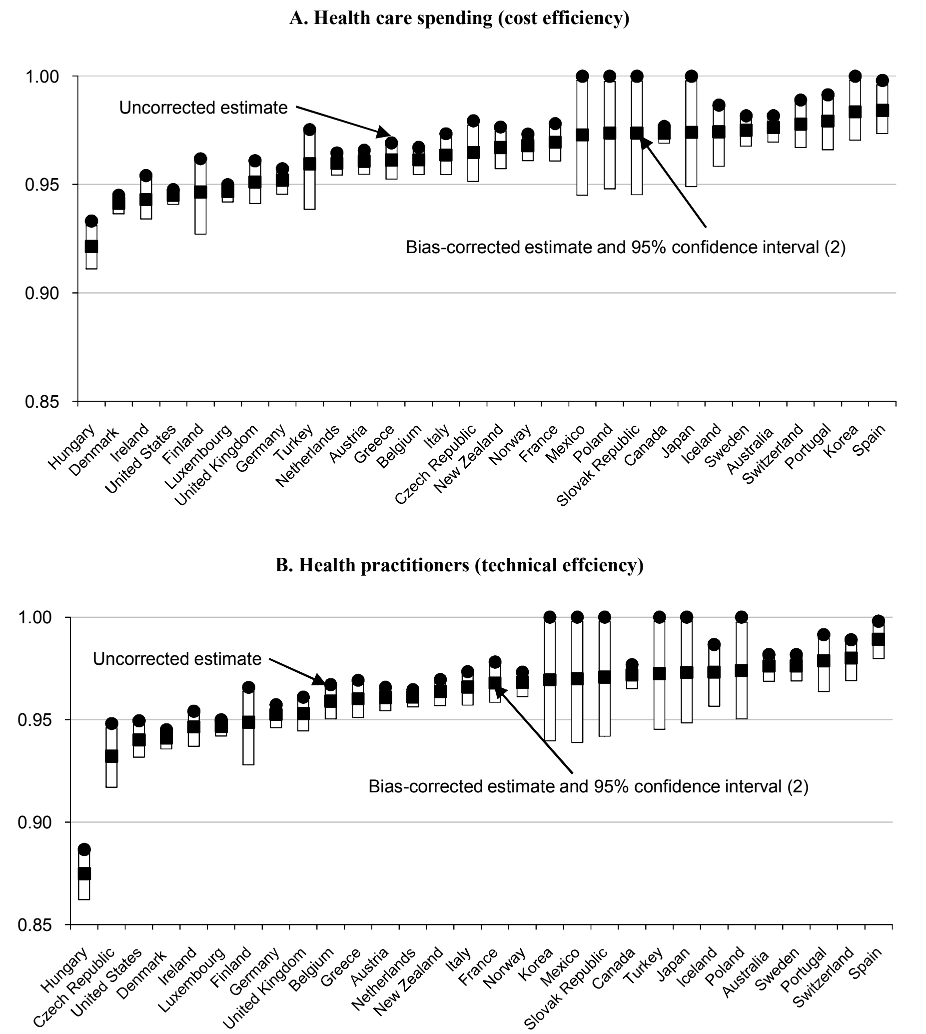
42. In line with panel data regressions, three main types of health status determinants have been introduced in the DEA:

- a health resources variable (alternatively health spending or health practitioners);
- a proxy for the Economic, Social and Cultural Status of the population (ESCS, see Annex 1 for more details),
- a lifestyle variable (diet).

The number of inputs has been restricted to three, to keep it sufficiently low relative to the size of the sample so as to provide sensible results from the DEA analysis. Inputs with a negative effect on the health status (such as smoking and alcohol) have also been avoided in the absence of an appropriate protocol to apply to this kind of input. The consumption of fruits and vegetables was thus retained as the only lifestyle variable although it was not always statistically significant in the regressions, as signalled above.

43. The DEA results again suggest that population health status could be improved significantly, while keeping inputs constant, in most OECD countries. Output-oriented efficiency scores across countries in 2004 show large variations, suggesting that LE at birth could be raised by 2 to 8% when health care resources are measured by the level of spending and by 1 to 12% when resources are measured by the number of health practitioners (Figure 11, Panels A and B). These results imply that LE could be raised by about five years in the least efficient countries, and that gains of around three years on average could be achieved in the OECD area.[33] Country scores are quite similar whether cost or technical efficiency is considered.

Figure 11. **DEA: output-oriented efficiency scores**[1]



1. DEA performed with three inputs (health care spending, ESCS, consumption of fruits and vegetables) and one output (life expectancy at birth).
2. DEA results are sensitive to measurement errors and statistical noise and plagued by a bias towards smaller inefficiency estimates. Booststrapping (i.e. taking repeated samples that have the same size as the existing data set) can help address these problems by making a correction for the small sample bias and producing confidence intervals.

Source: OECD calculations.

33. Some countries have launched important health care reforms since 2004 and/or raised health care resources which are likely to have an impact on spending effectiveness (in one way or another). Among the countries concerned are: Canada, Germany, the Netherlands, Germany and the United Kingdom.

44. The group of good performers according to the DEA broadly coincides with good performers according to panel data regressions. Australia, Iceland, Korea and New Zealand are consistently among the best performers. At the other end of the spectrum, Denmark, Hungary and the United States consistently score poorly. For a few countries, however, the results are somewhat conflicting. Using the DEA scores, Finland and Ireland, and to a lesser extent Greece, appears relatively inefficient, while panel data regressions suggest more sanguine conclusions. It should be acknowledged, however, that these two approaches are not fully comparable. In particular, they have not been applied to the same time horizons: the DEA is implemented on a cross-section and shows a "picture" of the situation in 2004, whereas panel data econometrics combines cross-sections and time series.

45. DEA and panel data econometrics can also be compared by deriving estimates of potential health gains in terms of additional years of LE for each method. Figure 12 shows that the two techniques give a broadly consistent picture of the gains, as measured by the number of years of life that could be saved, if efficiency were to be raised to the level implied by the estimated efficiency frontier.[34]

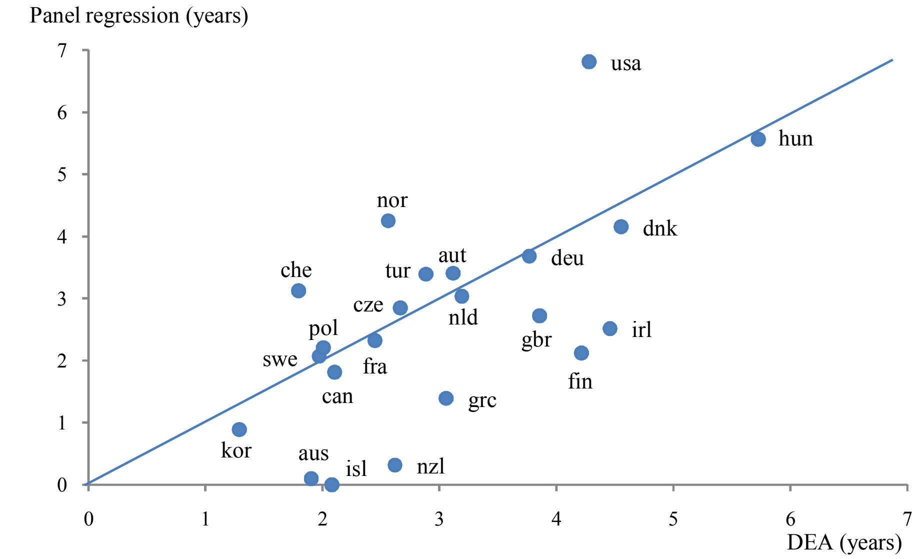
Overall findings and implications for future research

46. The results of statistical analyses and country rankings should be interpreted with caution. Data limitations are serious. Given the lack of consistent indicators accounting for morbidity and disability, efficiency assessment can fail to account for cross-country differences in the contribution of health expenditure to relieve symptoms and improve functional ability as well as quality of life. In addition, efficiency measures derived from panel data regressions are residuals, measuring the part of health status variables which cannot be explained by the model. Though the model has been designed to include as many of the factors influencing health status as possible, the "unexplained" component might partly capture factors other than efficiency, so that it should probably be taken as an upper limit for potential efficiency gains. Similarly, the small size of the sample imposes a limit on the number of variables included in the DEA and omitting variables could affect efficiency scores. DEA probably also tends to overstate the efficiency of countries which have few comparable counterparts in the sample, in particular those with the lowest levels of health spending (*e.g.* Mexico, Poland and Turkey). In any case, the DEA and panel regressions do not allow the identification of an optimal level of health care resources for society.

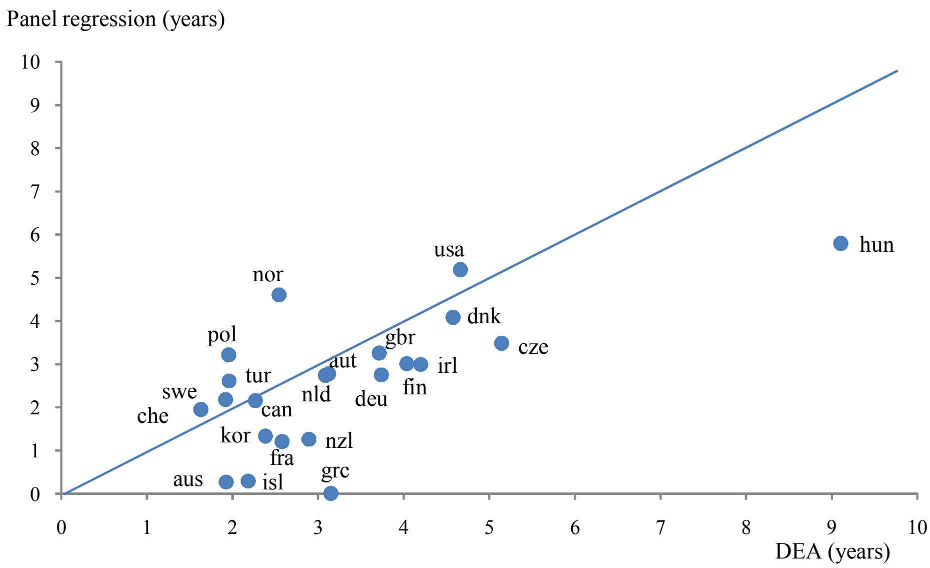
34. The DEA process provides estimates of how much life expectancy could be raised while keeping inputs constant. Similarly, panel data regressions can be used to derive estimates of the country-specific components of life expectancy which, given the country's inputs, cannot be explained by the model estimated for the OECD area. Comparing these country-specific components allows the best performing country to be identified, and this country is then used as a benchmark.

Figure 12. **Comparing DEA and panel data regression results: potential gains in life expectancy at birth**[1]

A. With health care resources measured in monetary terms



B. With health care resources measured in physical terms



1. Potential gains are measured as the number of years of life that could be saved if efficiency in country i were to be raised to the level implied by the estimated efficiency frontier (DEA) or were equal to the level calculated for the best performing country (panel regressions).

Source: OECD calculations.

47. Explaining the relative health-sector performance of OECD countries remains challenging at this stage but some general points seem to emerge. *First*, no relation exists between relative efficiency performance and the level of health spending. Among the best performers are both high-spending countries (including Australia and Iceland) and low-spending countries (Korea). The same mix of high and low spending is found at the opposite side of the efficiency scale. *Second*, high- and low-performing countries are not demarcated by differences in the mix of public and private spending in total spending. As an illustration, for the high performers, the public spending share ranged from just above 50% (Korea) to 82% (Iceland) in 2003. Roughly the same range applied to the group of low performers.

48. A further observation relates to the possible institutional determinants of health spending effectiveness. There seems to be no correlation between relative performance and some of the key institutional variables for which data are available in *OECD Health Data*, such as the share of the population covered by health insurance for a core set of services – possibly because near-universal coverage has been achieved in all but a few countries – or the relative importance of out-of-pocket payments (Table 7). Also, the traditional grouping of countries into three main health models -- public-integrated; public contract; private insurance/provider -- does not help to understand relative performance.[35] Denmark, Iceland and Norway have implemented very similar health models, very close to a public-integrated model. Their relative performance as derived in this paper, however, differs vastly. Future work should thus aim at a better definition and understanding of the links between institutions and performance of the health care system.

Table 7. **Some key institutional variables**

2004 or latest year available

	Public share of total expenditure on health	Health insurance coverage for a core set of services		Population covered by private health insurance[1]	Out-of pocket payments share of total expenditure on health
		Government	Primary private		
Australia	67.5	100.0	0.0	42.9	20.1
Austria	75.6	98.0	..	..	16.6
Belgium	73.1	99.0	..	44.0	20.6
Canada	70.2	100.0	0.0	66.0	14.6
Czech Republic	89.2	100.0	..	0.0	10.4
Denmark	84.3	100.0	0.0	5.4	14.1
Finland	77.2	100.0	0.0	..	18.3
France	79.4	99.9	0.0	87.2	7.2
Germany	76.9	89.8	10.0	23.2	13.2
Greece	44.6	100.0	0.0	15.6	..
Hungary	70.5	100.0	0.0	0.0	24.0
Iceland	82.4	100.0	0.0	13.9	17.6
Ireland	78.2	100.0	0.0	50.8	14.2
Italy	75.8	100.0	0.0	..	21.1
Japan	81.7	100.0	0.0	..	17.3
Korea	52.6	100.0	0.0	..	38.1
Luxembourg	90.2	99.7	0.0	..	7.4
Mexico	46.4	51.0	0.0	4.8	50.6
Netherlands	62.5	62.5	35.4	92.7	7.8
New Zealand	77.2	100.0	0.0	32.7	16.8
Norway	83.6	100.0	0.0	0.0	15.6
Poland	68.6	..	0.0	..	28.1
Portugal	72.0	100.0	0.0	16.7	22.5
Slovak Republic	73.8	95.6	0.0	0.0	19.2
Spain	70.9	..	..	11.9	22.7
Sweden	84.6	100.0	0.0	..	..
Switzerland	58.5	100.0	0.0	32.5	31.8
Turkey	72.3	..	0.0	1.2	19.2
United Kingdom	86.3	100.0	0.0	11.0	..
United States	44.7	27.3	59.2	67.1	13.3
Average	72.4	93.4	4.0	28.2	19.3

1. Primary, supplementary, complementary or duplicate private health insurance.
Source: OECD Health data 2007.

35. See Docteur and Oxley (2003). The *public-integrated model* combines on-budget financing of health care provision with hospital providers that are part of the government sector. In the *public-contract model*, public payers contract with private health care providers. A *private insurance/provider model* uses private insurance combined with private (often for profit) providers. While many systems feature a mix of elements, normally one of these models is dominants.

GLOSSARY

AIRPOL	Emissions of nitrogen oxide (NOx) *per capita* in kgs
AMI	Acute Myocardial Infarction
DEA	Data Envelopment Analysis
DFLE	Disability Free Life Expectancy
DRINK	Alcohol consumption in litres *per capita*
DIET	Consumption of fruits and vegetables *per capita* in kgs
EDU	Share of the population (aged 25 to 64) with at least upper secondary education
ESCS	Economic, Social and Cultural Status
HALE	Health-Adjusted Life Expectancy
HCQI	OECD Health Care Quality Indicator
HCR	Health Care Resources *per capita*, either measured in monetary terms (total spending including long-term care at GDP PPP exchange rates and constant prices) or in physical terms (*e.g.* health practitioners)
ISCED	International Standard Classification of Education
LE	Life Expectancy
NOx	Nitrogen Oxides
SFA	Stochastic Frontier Analysis
SMOK	Tobacco consumption in grams *per capita*.
PYLL	Potential Years of Life Lost
PPP	Purchasing Power Parity
WHO	World Health Organisation

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ANNEX 1: DEFINITIONS AND SOURCES

Health status indicators

Premature mortality, potential years of life lost (PYLL) and adjusted PYLL

49. Premature mortality focuses on the life years lost before 70, with deaths weighted according to their prematurity preceding 70. With this age limit, the death of an infant (70 life-years lost) will be given 14 times the weight given to the death of a 65-year old (five years lost). This contrasts with conventional mortality rates which implicitly attribute the same weight to all the deaths irrespective of age.

50. In order to assure cross-country and trend comparison, the Potential Years of Life Lost (PYLL) are standardised, for each country *i* and each year *t* as follows:[36]

$$PYLL_{it} = \sum_{a=0}^{l-1} (l-a)(d_{at} / p_{at})(P_a / P_n)*100000$$

where *a* represents age, *l* is the upper age limit chosen for the measure (70 years in *OECD Health Data*), d_{at} is the number of deaths at age *a*, p_{at} refers to the number of persons aged *a* in country *i* at time *t*, P_a refers to the number of persons aged *a* in the reference population, and P_n refers to the total number of persons in the reference population. The total OECD population in 1980 is taken as the reference population for age standardisation.

51. Data on premature mortality are available for most OECD countries, with the main exception of Turkey, over the period 1960-2004. However, data are missing for part of this period for many countries, in particular Belgium, the Czech Republic, Korea, Mexico and the Slovak Republic.

52. Premature mortality data include deaths which are caused by such external factors as land transport accidents, accidental falls, suicides and assaults. In the empirical work, these causes of death have been excluded to derive the "adjusted PYLL" indicator.

Infant, neonatal and perinatal mortality rates

53. Infant, neonatal and perinatal mortality rates focus on the health system capacity to prevent deaths at the youngest ages. Infant mortality refers to the number of deaths of children under one year, expressed per 1000 live births. Perinatal mortality refers to the number of deaths of children within one week of birth (early neonatal deaths) plus foetal deaths (deaths of foetuses of a minimum gestation period of 28 weeks or a minimal weight of 1000 grams), expressed per 1000 births. Neonatal mortality is the number of deaths of children under 28 days of age in a given year, expressed per 1000 live births.

36. Most of this information comes from *OECD Health Data 2007*.

54. Definitional issues complicate international comparisons for these indicators. Some of the international variations in neonatal, and to a lesser extent, infant mortality rates may be due to differences in the definition of a live birth (whether they are reported as live births or foetal deaths). In several countries, such as in the United States, Canada and the Nordic countries, very premature babies with relatively low odds of survival are registered as live births -- this increases mortality rates compared with other countries that do not register them as live births.

55. The definitional issue is partially avoided in the case of perinatal mortality, which includes both late foetal deaths and early (neonatal) infant deaths. The United States fare slightly better in the rankings when using perinatal mortality. However, large variations persist in how the minimum gestation period is accounted for in perinatal mortality rates across OECD countries. In principle, all deaths should be accounted for after a minimum gestation period of 28 weeks, or when a minimums foetal weight of 1000g has been reached. However, since 2002 France has defined the minimum gestation period as 22 weeks, or a minimum foetal weight of 500g, resulting in the poor ranking of France in this area. Breaks in series are more frequent for perinatal than for infant mortality rates. Furthermore, with the increasing number of women deferring childbearing and the rise of multiple births linked to fertility treatments, the number of pre-term births has tended to increase, affecting in particular perinatal mortality rates. But this should not be interpreted as contributory factors to poorer health. It is for these reasons that this paper focuses on infant mortality rather than neonatal or perinatal mortality.

Life expectancy

56. Several indicators of life expectancy are available for all OECD countries over the period 1960-2005 by gender and at different ages (the period covered differs according to countries and age retained). The paper mainly focuses on life expectancy at birth and at 65 (given the concentration of health expenditure on people aged 65 and above) for the total population and broken down by gender.

Health-Adjusted Life Expectancy

57. To calculate the Health-adjusted Life Expectancy (HALE), the World health organisation (WHO) weights the years of ill-health according to severity and subtracts them from overall life expectancy to give the equivalent years of healthy life. *OECD Health Data* contains data only for 2002 and 2000 and, since different data sources have been used for 2000 and 2002, comparisons across time cannot be drawn. In this context, HALEs cannot be used in panel regressions.

Disability Adjusted and Disability Free Life Expectancy (DALE and DFLE)

58. DALE is defined as life expectancy adjusted for the average time a person has lived with some disability (weighted for severity).[37] *OECD Health Data* does not contain data for DALE. It does, however, contain data for Disability-Free Life Expectancy (DFLE), for 16 European/OECD countries for 2003, with DFLE being defined as the absence of limitations in functioning/disability. Because severe and other disabilities are treated equally, DFLE is a less relevant measure than DALE.

37. It should be noted that social values impinge on the definition of disability and weights assigned to each disability. The WHO calculated DALE for the first time in the *2000 World Health Report* and used DALE for the study on the effectiveness of health care systems. Self and Grabowski (2003) also used DALE produced by the WHO when assessing the cost-effectiveness of public spending across countries.

Other health outcome indicators

Sick leaves

59. Data availability on sick leave is rather limited: ten countries provide data on the number of sick days lost and compensated for over the period 2000-2005, and information on self-reported absences from work owing to illness is even less complete.

Avoidable deaths

60. The concept of avoidable deaths -- *i.e*. deaths that should not occur in the presence of effective and timely health care -- is another promising approach to addressing the question of the degree to which health care contributes to population health (Nolte and McKee, 2004). Measuring "avoidable deaths" requires establishing a list of conditions considered amenable to health services and setting age limits for each condition (*e.g*. diabetes mellitus under age 50 and tuberculosis under age 75). Many lists have been proposed since the Working Group on Preventable and Manageable Diseases in the United States introduced the notion of "unnecessary untimely deaths" in the 1970s.[38] Some have evolved through time, partly reflecting medical progress in knowledge and technology. So far, however, there are no avoidable death data in *OECD Health Data*.

Disease-based indicators from the HCQI project

Breast cancer survival rates

61. Through early detection and appropriate treatment, health care systems can significantly improve the prognosis of some cancers. Breast cancer is a key example and is also the most common form of cancer for women and a leading contributor to health care costs.[39] Thus, comparing survival rates for breast cancer may provide some insight into the performance of different health care systems, more than survival rates for types of cancers which are difficult to cure, even in the presence of a timely and efficient health care system -- lung cancers for instance.

62. Data on the five-year relative survival rate for breast cancer patients were collected in the context of the OECD project on Health Care Quality Indicators (HCQI). The data are available for 19 countries, but cover rather different periods, some of which end many years ago, making it very difficult to draw cross-country comparisons. In particular, by using these data, France, Germany, Japan and Switzerland could be ranked among the poorest performers. However, the data for these countries are more than ten years old, a period over which medical progress has greatly improved the prognosis of people with cancer (*e.g*. data for France and Switzerland cover the period 1990-94). This can be seen in the mortality rates for France and Switzerland, where breast-cancer related deaths declined by 12 and 32% respectively in the period 1994-2003. Differences in methods for age standardisation rates may further complicate cross-country comparisons (Kelley *et al.*, 2007).

In-hospital case-fatality rates following AMI, ischaemic and hemorrhagic strokes

63. Much of the reduction in mortality over the recent decades can be attributed to lower mortality from acute myocardial infarction (AMI) as a result of better treatment in the acute phase. *OECD Health*

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38. See Nolte and McKee (2004) for an excellent literature review, and Charlton *et al.* (1986), Pokolainen and Eskola (1988), Simonato *et al.* (1998).

39. *OECD Health Data 2007* also contains data on five-year relative survival rates for cervical cancers for 19 OECD countries and for colorectal cancer for 11 countries, but in both cases the time periods differ.

Data suggests that AMI accounted for 11% of the decline in total premature mortality over the period 1990-2002 in the OECD area. AMI in-hospital case-fatality rates are further regarded as a good outcome measure of acute care quality because of the variety of services and system devices that need to be mobilized to provide care for this illness and have been used for benchmarking hospitals in several countries, including the United States (Agency for Healthcare Research and Quality) and the United Kingdom (NHS).

64. Stroke is also a very common cause of death and disability in OECD countries, though case-fatality rates have declined in many countries. As with AMI, stroke case-fatality rates have been used for hospital benchmarking within and between countries. Two types of stroke have been distinguished in the HCQI project: ischemic and hemorrhagic strokes.

65. Data on AMI, ischemic and hemorrhagic strokes in-hospital fatality rates have been collected for the HCQI project and are available, respectively, for 24, 23 and 22 countries (Kelley *et al.*, 2007; *OECD Health at a Glance*, 2007).

Public satisfaction with the health care system

66. Data on public satisfaction are available in *OECD Health Data*, mainly for EU countries. They cover a maximum period of two or three years.

Measures of health inputs

Lifestyle factors

Tobacco consumption

67. *OECD Health Data* contains three variables which could be used as proxies for harmful tobacco consumption:

1. annual consumption of tobacco items in grams per person aged 15 years or over;
2. average number of cigarettes per smoker per day;
3. share of daily smokers in the population aged 15 years or more.

The last variable is the only one available by gender but it also seems less relevant since it does not account for the consumption per smoker. It is actually poorly correlated with the overall consumption of tobacco. As an example, the Czech Republic is the OECD country with the second highest tobacco consumption (measured in grams *per capita*) but ranks only fourteenth for the percentage of adult population smoking daily.

68. In most of the regressions, tobacco consumption is measured by the annual consumption of tobacco in grams per person aged 15 years or over. Data are available for 24 countries, but cover different time periods depending on countries. Berger and Messer (2002) as well as Or (2000b) adopted the same measure. Other measures have, however, been used in several other studies, including the percentage of regular smokers among men and women over 15 (Crémieux *et al.*, 1999), and spending on tobacco (Grubaugh and Santerre, 1994, and Or, 2000a). Replacing the annual consumption of tobacco by the share of daily smokers, by gender, does not change our results, however.

Alcohol consumption

69. *OECD Health Data* contains data on the annual consumption of pure alcohol in litres per person aged 15 years and above. Data are available for all OECD countries but cover different time periods.

Average *per capita* consumption may, however, fail to account for a particularly dangerous pattern of consumption -- consumption of large quantities of alcohol at a single session ("binge drinking") -- which is on the rise in some countries and social groups.

Diet

70. Only a minority of empirical studies have included diet in the health production function and there is no consensus in these studies on what would be the best proxy for diet. *OECD Health Data* contains four proxies for diet: intake of calories, sugar, fat, and fresh fruits and vegetables. Introducing the first three proxies raises at least two problems: *i)* the consumption of calories, sugar and fat is likely to have a non-linear effect on health -- it contributes positively up to a certain level but beyond becomes detrimental; *ii)* these three variables are highly correlated with GDP *per capita*, thus potentially biasing estimated coefficients. The consumption of fresh fruits and vegetables appears to be largely immune from these problems and has been the proxy chosen for the empirical work. Alternative specifications have been tested, replacing the consumption of fruits and vegetables by calorie or fat intakes but they led to unstable or inconsistent coefficients.

Obesity

71. Obesity is sometimes considered as a determinant of the population health status because it can be considered as a proxy for a broad range of nutritional and physical activity patterns. In practice, obese people tend to die at a younger age. Data on obesity are, however, not easily comparable: 28 countries collect data for obesity but on a very irregular basis. Furthermore, in some countries data refer to self-reported status, while in others they are derived from actual heights and weights. More fundamentally, one could question whether obesity should be considered as a determinant of the population health status (*i.e.* a right-hand side term of the health status production equation) or instead as a measure of the health status itself (left-hand side term). It is clear, in practice, that obesity is influenced by education, income, lifestyle factors and, though probably less, by health-care resources.

Socio-economic factors

Pollution

72. *OECD Health Data* contains three proxies for air pollution: sulphur oxide emissions, nitrogen oxide emissions (NOx) and carbon monoxide emissions. The choice of NOx as the proxy for pollution in our empirical work has been mainly dictated by the difficulty to derive long-enough time series for the other two measures.[40] To build time series for the NOx, information contained in *OECD Health Data* (available for most OECD countries over the period 1990-2002) has been combined with data published by the EMEP (Co-operative programme for monitoring and evaluation of the long range transmission of air pollutants in Europe). On the basis of NOx *per capita*, air quality is the lowest in Australia, Canada, Iceland and the United States. Had sulphur oxide emissions been chosen as a proxy for pollution, country relative ranking would have been somewhat different. It should be noted however that Australia, Canada and the United States are also the countries with the highest sulphur oxide emissions *per capita*.

Education

73. *OECD Health Data* contains two main proxies for education: educational attainment (percentage of the adult population, 25 to 64 years old, that has completed a certain level of education defined according to the ISCED system) and school expectancy (defined as the expected years of schooling under

40. Or (2000a) also selected NOx emissions *per capita* as an approximation of air pollution.

current conditions calculated through enrolment rates). Data on the average effective number of school years are also available from Bassanini and Scarpetta (2002) and *OECD Education at a glance*. Previous empirical studies have selected different options. Educational attainment was used by Thornton (2002) and Self and Grabowski (2003). The average number of schooling was used by Or *et al.* (2005) as well as by Puig-Junoy (1998). Confronted with the difficulty of getting time series on education, Or (2000a) used the share of white-collar workers in the total workforce as a proxy for social and educational status.

74. The choice of a particular measure may affect country rankings significantly. As an illustration, in Australia less than 63% of the population aged 25-64 has at least attained upper secondary education, but on average each student remains over 12 years in the educational system which, compared to other countries, is rather high. Both for educational attainment and school years, there are significant data gaps. For the empirical work, we have considered that the educational attainment level (share of the population that has attained at least upper secondary education) was the best proxy for the contribution of human capital to health. Data in *OECD Health Data* are available for all countries but start rather late in the 1990s. To obtain longer time series, an earlier OECD historical database was used.

Economic, Social and Cultural Status (ESCS)

75. To minimise the number of inputs, preference has been given for DEA to the PISA index of the economic, social and cultural status (ESCS), instead of education and income levels. This index is designed to capture broad aspects of a student's family and home background. It is derived from sub-indices based on: *i)* the highest occupational status of the students' parent; *ii)* the highest level of education of the parents; and *iii)* an index based on educational resources in the home and the number of books at home. The ESCS index is centred and hence can be positive or negative. As the non-parametric approach cannot be performed with zero or negative numbers, the ESCS index was rebased.

Health care resources

Spending on health care

76. OECD Health Data series for total expenditure on health per capita were used. For several countries (in particular Austria, Belgium, Finland, France and Turkey), these data include series breaks. To cope with this issue, the growth rate in the break year was replaced by the average growth rate in the preceding 5 years (a proxy for trend growth). The levels before the break year were revised by retropolation using actual growth rates (those of the unadjusted series).

77. To convert health care spending into volume measures which are comparable across countries, previous studies have relied on different approaches. Most studies have relied on GDP PPPs but some have used existing health care PPPs (*e.g*. Or, 2000a; Miller and Frech, 2002). Existing health-specific PPPs are, however, flawed with several drawbacks. For health services, only "market" outpatient services are covered by price surveys but international comparability of these data is less than perfect, in particular for countries where the share of the private sector is low. In the absence of output prices for hospitals, an input-price approach is applied but it assumes that productivity is equal across countries. Recognising the drawbacks of existing data, the OECD has launched a work programme to develop health-specific PPPs. In the meantime, GDP price deflators and PPP exchange rates for the base year (2000) have been used to convert health spending in this empirical work.

78. Data on health care spending include long-term care. While it may have been desirable to exclude this component when estimating the impact of health care on the health status, it is in practice quite difficult. Total expenditure on long-term care is available for ten countries from 2003 on but only for two

countries before 2003. While total expenditure on long-term nursing in-patient care could be a proxy, it is available for 20 countries in 2003 but only 11 in 1980.

79. Health care spending has been broken down by category: pharmaceuticals, outpatient care, inpatient care and other, using the data available in *OECD Health Data*. Differences in institutional arrangements and categorization of spending may, however, blur the picture. Peterson and Burton (2007) noted that in the United States it is common for physicians to provide inpatient hospital care while not being employees of the hospital. For categorising US spending, these physician services are considered outpatient services, even though they are provided in an inpatient setting. The result is that the United States appears to have a higher proportion of outpatient spending that it otherwise would. In other OECD countries (including Australia, Japan, Mexico and the Netherlands), some spending items have been re-classified over time between outpatient and inpatient care, creating series breaks.

80. Health care spending could be broken down into public and private components but in the current work, it was decided not to do it. The different treatment of tax expenditures across countries, a rather large item in some, may introduce serious bias. In principle, tax expenditures are included in the data for total health care spending. The current OECD manual on the System of Health accounts is not clear, however, on how to deal with tax expenditures and therefore countries interpret it differently. Australia and Germany, for instance, deduct tax expenditures from the private insurance expenditures and report it as public expenditure. But in the United States, tax expenditures are not considered as public expenditure. According to Peterson and Burton (2007), they amounted to $141.5 billion in 2006 (*i.e.* over 1% of GDP), and include tax exemption of employers' contributions for employee health insurance ($90.6 billion) and deductions for out-of-pocket medical expenses ($7.3 billion).

Human resources

81. *OECD Health Data* contains data on health employment while underlining the fact that cross-country comparisons should be carried out with care. Data can be on a head count basis in some countries and on a full-time equivalent basis in others; they may include or not professionals who are foreigners, non-practising or retired professionals. In the same way, data on practising nurses may or may not include non-practising nurses, midwives or self-employed nurses.

82. Physicians and nurses account for the largest share of health practitioners in many countries. Still, their number *per capita* varies a lot *across countries*, as does the ratio of nurses to doctors. In contrast, the ratio of nurses to doctors is rather stable *across time* within countries. Hence, in order to use a less restrictive measure of health employment resources than practising physicians, a human resource indicator was constructed and used for both the panel regressions and the DEA. It has been built by summing up the number of physicians and half the number of nurses (reflecting the fact that many nurses work part-time and that their productivity may be lower than the productivity of practising physicians, as partial evidence on wage levels would suggest).

Gender and age dimensions

83. While gender-specific health status measures have been used, input variables are not gender specific. Tobacco is the only input for which we could have derived gender-specific time series. Information on the share of daily smokers in the population aged above 15, available by gender, was however regarded as less relevant than tobacco grams consumed per person aged 15 and above -- the series used in our empirical work, but not available by gender. Similarly, health status measures by age have been used but age-specific input measures are not available. In particular, spending may well have increased more for older groups and the distribution of spending across age groups differs across countries.

ANNEX 2. SELECTED EMPIRICAL WORK: APPROACHES AND MAIN RESULTS

Selected empirical works: Approaches and main results

Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
Afonso and St Aubyn (2006)	30 OECD countries Period: early 2000s Two-step procedure on cross-section data: DEA and Tobit regressions	A principal component consisting of life expectancy at birth, infant mortality and premature mortality.	A principal component consisting of doctors, hospital beds, MRI in the DEA. Tobit regressions include: GDP *per capita;* education; tobacco, alcohol and sugar consumption and obesity.	GDP *per capita*, education level and tobacco and obesity help to explain why some countries achieve better health status than others while using comparable levels of health care resources.
Berger and Messer (2002)	20 OECD countries Period: 1960-92 Panel data regressions	Mortality rates	Income; income distribution; age structure; tobacco, fat and alcohol consumption, education; income inequalities. Health care spending; share of public spending; public insurance coverage for inpatient and ambulatory care.	Increases in health care expenditure are associated with lower mortality, as are healthier lifestyles, higher education. Income inequality does not play a role. Increases in the publicly financed share of health care expenditure are associated with higher mortality rates. Increased insurance coverage for ambulatory care reduces mortality rates; the impact of insurance coverage for inpatient care is less clear.
Crémieux *et al.* (1999)	10 Canadian provinces Period: 1978-1992 Panel data regressions	Infant mortality; male and female life expectancy	GDP *per capita*; education; tobacco; meat and fat consumption; poverty. Number of physicians *per capita*; health care spending *per capita.*	Lifestyle factors are significant determinants of health outcomes. Education has little impact on health status. Income is a determinant of life expectancy. A lower number of physicians or/and cuts in spending is associated with increased infant mortality and reduced life expectancy. A 10% spending cut would be associated with a 6 month reduction in life expectancy for men and 3 months for women.

Selected empirical works: Approaches and main results (*cont.*)

Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
Elola *et al.* (1995)	17 European countries Cross-section regressions	Life expectancy and premature mortality (PYLL) by sex; infant mortality	GDP per capita; Health care spending; type of health system (social security *versus* integrated national health service).	*Per capita* health care spending may explain more variance in infant mortality than would per capita GDP. Health care spending are inversely correlated to female premature mortality and positively correlated to female life expectancy. Income distribution is not an explanatory variable for variations in health status among European countries. Countries with national health services are more efficient at producing lower infant mortality rates than those with social security systems. But there is no statistical relation between health system organisation and other health status variables.
Filmer and Pritchett (1997)	109 developing countries Cross-section regressions	Child (<5) and infant mortality	GDP *per capita*, female education, income inequality, degree of urbanization, religious affiliation, ethno-linguistic fractionalisation, access to safe water. Public spending share in total health care spending.	95% of cross-national variation in mortality can be explained by a country's income *per capita*, the distribution of income, female education, ethnic fragmentation and predominant religion. The impact of public spending on health is small and insignificant.
Hitiris and Posnett (1992)	28 OECD countries Period: 1960-87 Panel data regressions	Mortality rates	GDP per capita, per capita health spending, share of population over 65.	Mortality is negatively related to per capita health spending but the elasticity is very low (0.08 to 0.06, depending on the PPP exchange rate).

Selected empirical works: approaches and main results (*cont.*)

Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
Nixon and Ullman (2006)	15 EU countries Period: 1980-95 Panel data regressions	Life expectancy at birth and infant mortality	Unemployment rate, alcohol, tobacco, diet and pollution. Health spending *per capita* and as a share of GDP, number of physicians, hospital beds, in-patient admission rate and average length of stay, insurance coverage of the population.	Results show a marginal but positive effect for health expenditure on health outcomes for EU countries. Change in health care expenditure and number of physicians have added 2.6 and 1.6 years respectively to male life expectancy in EU countries. And to a 0.63 and 0.22 percentage point decline in the infant mortality rate.
Or (2000a)	21 OECD countries Period: 1970-1992 Panel data regressions	Premature mortality (potential years of life lost – all causes except suicides)	GDP *per capita*; occupational status; alcohol, tobacco, fat and sugar consumption. Total health spending *per capita*; share of public spending.	The rise in the employment share of white collar workers and the rise in *per capita* income play the greatest role in the reduction of premature mortality between 1970 and 1992. There is a significant and positive relation between health expenditure and health status, particularly for women. Since the public share of expenditure has remained fairly constant, its contribution to the decline in premature mortality has been negligible.
Or (2000b)	21 OECD countries, 1970-95 Panel data regressions	Various mortality variables (infant mortality, perinatal mortality, PYLL and specific PYLL by sex, life expectancy at age 65)	Alcohol and tobacco consumption, GDP *per capita*, occupational status (share of white collars) and air pollution. Number of doctors, public *vs* private financing, provider payment systems at the hospital and individual level, access arrangements (gatekeeper role).	A high number of doctors per capita is associated with lower rates of premature mortality, lower perinatal and infant mortality, and in particular longer life expectancy at 65 and lower heart diseases. A high share of public financing is associated with lower premature mortality and infant and perinatal mortality but does not affect LE at 65 or heart diseases.

Selected empirical works: Approaches and main results (*cont.*)

Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
				Institutional variables for funding arrangements are often not significant, with some exceptions: countries with fee-for-service at the hospital level tend to have lower premature mortality (but not longer LE at 65).
Or *et al.* (2005)	21 OECD countries, 1970-98 Period: Panel data regressions	Life expectancy at birth and at 65, premature mortality from heart diseases	Alcohol and tobacco consumption, GDP *per capita* and education. Number of doctors and medical equipment, public spending share, provider payment systems in the hospital and ambulatory sectors, gate-keeping role of physicians.	The impact of health care (measured by the number of doctors) varies significantly across countries. There is some tendency for countries which pay their primary doctors by fee-for-service to be more efficient than those which pay doctors by salary or capitation. The public/private mix and gate-keeping do not play a significant role.
Puig-Junoy (1998)	OECD countries Period: 1960-1990 Two-steps procedure on panel data: DEA and tobit regressions	Life expectancy at birth	Tobacco and alcohol consumption. Number of physicians and non-physician health care employees, number of hospital beds health care.	Non-efficient countries use, on average, about 40% more inputs than efficient countries (for similar outputs). Inefficiency can be divided up into pure inefficiency and scale inefficiency (*i.e.* associated with non-increasing returns to scale). Tobit regression results for DEA efficiency scores are significantly and positively correlated with the share of health care expenditure that is privately financed and average years of schooling but not correlated with a dummy representing the gatekeeping role of GPs.

Selected empirical works: Approaches and main results (*cont.*)

Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
Retzlaff-Roberts *et al.* (2004)	27 OECD countries, 1998 DEA, with constraints on non-discretionary inputs	Infant mortality and life expectancy at birth (analysed separately)	School expectancy, Gini coefficient and tobacco use. Number of practicing physicians, inpatient beds, MRI units, health spending to GDP.	Inputs could be reduced by between 14 to 21% on average in the OECD area without raising the level of infant mortality or reducing life expectancy, respectively.
Self and Grabowski (2003)	A set of 191 developed countries, middle income countries and less developed countries Cross-country regressions	DALE as calculated by the WHO in 2000	Socioeconomic conditions (number of years of education, income, dependency ratio); lifestyle factors (calorie intake and the share of urban population), pre-existing health conditions. *Per capita* health expenditure segregated into its public and private components.	The impact of public health spending on the DALE is insignificant for the world overall as well as for the developed countries. In these countries, private spending does not either contribute to improve the DALE. The socioeconomic status and pre-existing health conditions play a major role. High calorie diets, a high degree of urbanisation and the dependency ratio have a negative impact.
Soares (2007)	A set of Brazilian municipalities 1970-2000 Panel data regressions	Life expectancy at birth, child mortality	Income *per capita*, urbanization, nutrition. Access to public medical care and immunization coverage.	Availability of health care infrastructure has a significant impact on life expectancy.
Spinks and Hollingsworth (2007)	28 OECD countries 1995-2000 DEA on panel data	Life expectancy at birth	Education, unemployment, income. Health care spending	Though country rankings are rather robust to changes in dataset, policy makers should be aware of the limitations and uncertainty of using DEA techniques.

Selected empirical works: Approaches and main results (*cont.*)

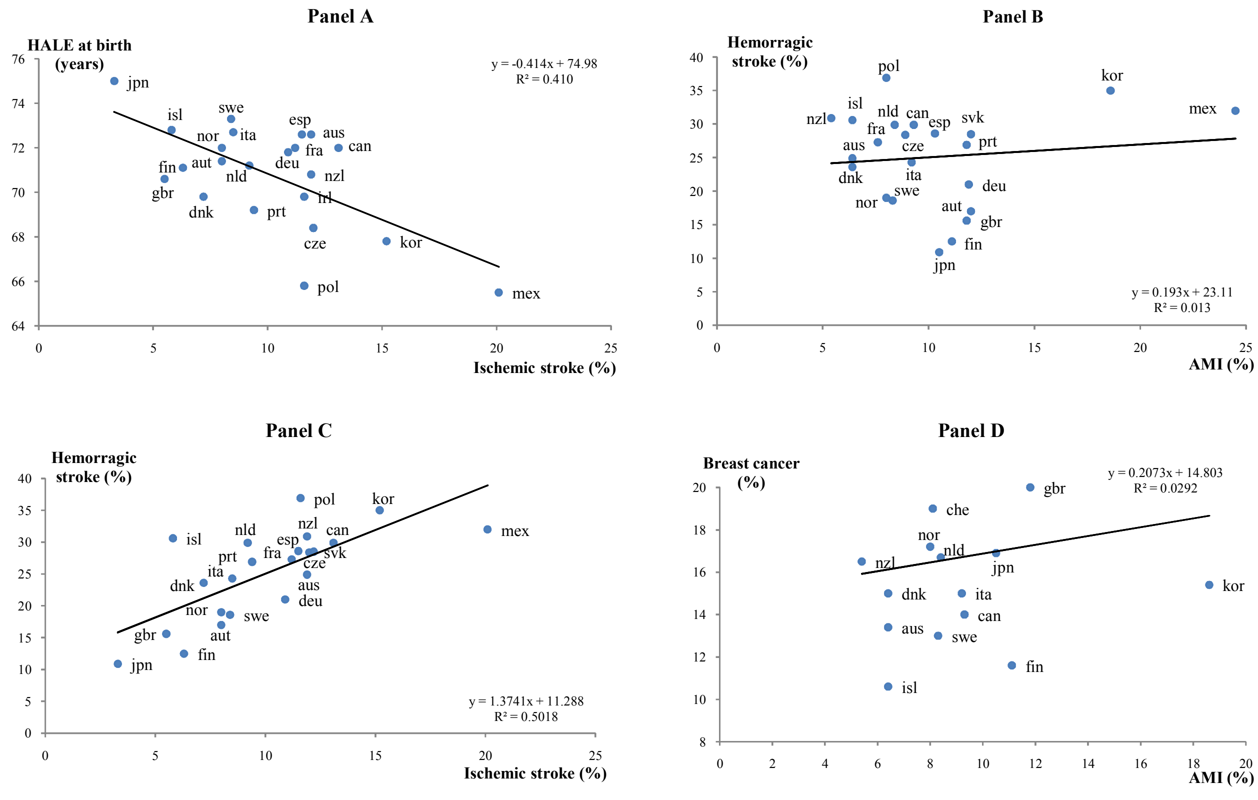
Authors	Sample, coverage, methods	Dependent variables	Main explanatory variables	Main results
Thornton (2002)	US states 1990 Cross-state regressions	Age-adjusted death rate	Income, education, smoking, alcohol, urbanization, manufacturing, marriage and crime. Health care spending.	The contribution of medical care in lowering mortality is quite small. Greater consideration should be given to the role of socioeconomic and lifestyle factors in preventing disease and improving life expectancy.
Verhoeven *et al.* (2007)	28 OECD countries 1998-2003 (averages) Two-steps procedure on cross-section data: DEA and bootstrapped truncated regressions.	Healthy life expectancy, standardised death rate, infant, child and maternal mortality rates.	Index of the countries' average ranks for number of hospital beds, physicians and health workers *per capita,* immunizations and doctors' consultations. Expenditures on inpatient care, private expenditure on health, density of general practitioners, GDP, caloric intake per day and share of urban population.	Inefficiencies in G7 countries mostly reflect the lack of cost effectiveness in acquiring real resources, such as pharmaceuticals. High wage spending is also associated with lower efficiency, while more frequent immunizations and doctors' consultations coincide with higher efficiency.
Studies focusing on pharmaceuticals				
Miller and Frech (2002)	18 OECD countries cross-country regressions	DALE and LE at birth and at age 60; premature mortality by sex	GDP *per capita*, share of smokers by gender, alcohol consumption, obesity. Spending on pharmaceutical, spending on other care items.	Pharmaceutical consumption is more powerful in extending DALE than life expectancy. Productivity of pharmaceutical consumption varies greatly by both cause of death and by age.
Shaw *et al.* (2002)	19 OECD countries 1999 Cross-country regressions	Life expectancies for males and females at ages 40, 60 and 65.	GDP *per capita*; alcohol, tobacco, butter and fruits and vegetables consumption. *Per capita* drug expenditure. (all explanatory variables are lagged by 15 years)	Pharmaceutical consumption has a positive effect on life expectancy.

ANNEX 3. ADDITIONAL ESTIMATION RESULTS

Correlations between fatality rates for selected diseases and HALE at birth

84. Relations across disease-based outcome measures, and between them and system-based health status measures, are discussed in the main text. Figure A3.1 shows some correlations.

Figure A3.1. **Fatality rates for selected diseases and HALE at birth**



Note: Data for health-adjusted life expectancy (HALE) at birth are for 2002. In-hospital case-fatality rates within 30 days after admission for acute myocardial infarction (AMI), ischemic or hemorragic stroke refer to the year 2005 or the latest year available. The five-year relative fatality rates for breast cancer cover very different periods: 90-94 for France and Switzerland; 93-96 for Japan; 93-97 for Germany; 94-98 for the Czech Republic; 95-99 for Italy; 96-00 for Iceland and the Netherlands; 98-01 for the United Kingdom; 98-02 for Australia, Korea and the United States; 98-03 for Canada, New Zealand and Norway; 99-03 for Finland; 99-04 for Ireland and Sweden; 2001-05 for Denmark.

Source: Health at a Glance, OECD indicators 2007.

Alternative specifications on health status determinants

85. Alternative scenarios have been examined to assess the robustness of the results in the face of the high degree of correlation between some explanatory variables and the possibly endogenous nature of some of them. As discussed in the main text, *per capita* income and spending, as well as educational attainment and lifestyle factors are often highly correlated. Three alternative scenarios have been produced:

4. In the first alternative scenario, GDP *per capita* has been withdrawn, assuming that most of its impacts are indirect, *i.e*. through health care resources, education and lifestyle factors.

5. In the second alternative scenario ("lifestyle"), only lifestyle factors, spending and pollution are accounted for, assuming that both the income and education levels have no impact, over and above these factors.

6. The third alternative scenario ("macro conditions") is basically the reciprocal: one may exclude lifestyle factors which are themselves first and foremost determined by educational attainment and income.

86. A close look at the results from these alternative scenarios suggests that most estimated coefficients are broadly stable in level and significance (Tables A.3.1. to A.3.8). There are some deviations, however. In the "lifestyle" scenario, estimated coefficients are generally higher but their significance is sometimes reduced. The estimated spending elasticity is also somewhat higher in models without GDP, reflecting the correlation between these two variables. When health care resources are measured by the number of practitioners, estimations are less stable across alternative scenarios.

Table A3.1. **Alternative scenarios for the determinants of life expectancy at birth** [1]

(Health care resources measured by health care spending)

Variables	1. Full model			2. Model without GDP			3. Lifestyle only (model without GDP & education)			4. Pure macro conditions model		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Constant	4.009***	3.641***	3.825***	4.037***	3.853***	3.928***	3.905***	3.739***	3.831***	3.962***	3.626***	3.814***
Spending	0.035***	0.045***	0.041***	0.038***	0.059***	0.049***	0.064***	0.083***	0.072***	0.032***	0.042***	0.037***
Tobacco	-0.000	-0.006**	-0.004	-0.000	-0.008***	-0.004*	0.008***	0.001	0.005**			
Alcohol	-0.011***	-0.014***	-0.011***	-0.010***	-0.008*	-0.008**	-0.020***	-0.025***	-0.025***			
Diet	0.003	0.004	0.004	0.003	0.006**	0.005**	0.006***	0.012***	0.009***			
Pollution	-0.009***	-0.018***	-0.012***	-0.009***	-0.019***	-0.012***	-0.008***	-0.013***	-0.010***	-0.014***	-0.027***	-0.019***
Education	0.029***	0.031***	0.030***	0.030***	0.038***	0.034***				0.020***	0.015***	0.018***
GDP	0.006	0.035***	0.019***							0.017***	0.043***	0.028***
Number of observations	325	325	325	325	325	325	424	424	424	444	444	444
Number of countries	23	23	23	23	23	23	24	24	24	30	30	30

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.2. **Alternative scenarios for the determinants of life expectancy at birth** [1,2]

(Health care resources measured by health practitioners)

Variables	1. Full model			2. Model without GDP			3. Lifestyle only (model without GDP & education)			4. Pure macro conditions model		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Constant	3.940***	3.652***	3.796***	4.228***	4.200***	4.220***	4.269***	4.224***	4.248***	3.827***	3.472***	3.639***
Practitioners	0.013***	0.017***	0.015***	0.025***	0.038***	0.034***	0.083***	0.105***	0.091***	0.028***	0.029***	0.027***
Tobacco	-0.009***	-0.018***	-0.0134***	-0.016***	-0.026***	-0.021***	-0.001	-0.006	-0.004			
Alcohol	-0.011***	-0.018***	-0.015***	-0.002	-0.010	-0.008	-0.007	-0.003	-0.004			
Diet	0.003	0.004	0.004	0.005	0.010***	0.009***	0.006*	0.009**	0.008**			
Pollution	-0.003	-0.012***	-0.006**	-0.002	-0.013***	-0.008**	-0.012***	-0.027***	-0.017***	-0.006***	-0.020***	-0.013***
Education	0.040***	0.045***	0.042***	0.056**	0.067***	0.058***				0.027***	0.022***	0.024***
GDP	0.035***	0.066***	0.050***							0.043***	0.079***	0.062***
Number of observations	254	254	254	254	254	254	303	303	303	347	347	347
Number of countries	22	22	22	22	22	22	23	23	23	29	29	29

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
2. Practitioners are calculated as the number of practicing physicians and half the numbers of practicing nurses.
   *** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.3. **Alternative scenarios for determinants of life expectancy at 65** [1]

(Health care resources measured by health care spending)

Variables	1. Full model		2. Model without GDP		3. Lifestyle only (model without GDP & education)		4. Pure macro conditions model	
	Female	Male	Female	Male	Female	Male	Female	Male
Constant	2.178***	1.638***	2.513***	2.290***	2.345***	2.276***	1.882***	1.106***
Spending	0.051***	0.061***	0.070***	0.111***	0.111***	0.140***	0.058***	0.090***
Tobacco	-0.019***	-0.057***	-0.025***	-0.063***	-0.009	-0.053***		
Alcohol	-0.017	-0.004	-0.004	0.020	-0.018**	-0.018		
Diet	0.013*	0.028***	0.014**	0.031***	0.016**	0.044***		
Pollution	-0.037***	-0.068***	-0.041***	-0.075***	-0.041***	-0.079***	-0.042***	-0.089***
Education	0.064***	0.045***	0.062***	0.058***			0.053***	0.026***
GDP	0.044***	0.107***					0.064***	0.128***
Number of observations	325	325	325	325	423	423	443	444
Number of countries	23	23	23	23	24	30	30	30

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.4. **Alternative scenarios for the determinants of life expectancy at 65** [1,2]

(Health care resources measured by practitioners)

Variables	1. Full model		2. Model without GDP		3. Lifestyle only (model without GDP & education)		4. Pure macro conditions model	
	Female	Male	Female	Male	Female	Male	Female	Male
Constant	2.093***	1.573***	2.901***	2.887***	1.879***	2.413***	1.550***	0.706***
Practitioners	0.032**	0.043***	0.064***	0.073***	0.185***	0.217***	0.060***	0.085***
Tobacco	-0.028***	-0.073***	-0.046***	-0.091***	-0.023***	-0.053***		
Alcohol	-0.024*	-0.010	0.000	0.029*	-0.01	-0.004		
Diet	0.002	0.008	0.003	0.026**	-0.001	0.026**		
Pollution	-0.032***	-0.058***	-0.030***	-0.063***	-0.051***	-0.097***	-0.028***	-0.077***
Education	0.056***	0.046***	0.102***	0.124***			0.044***	0.020**
GDP	0.099***	0.170***					0.125***	0.215***
Number of observations	254	254	254	254	303	303	347	347
Number of countries	22	22	22	22	23	23	29	29

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
2. Practitioners are calculated as the number of practicing physicians and half the numbers of practicing nurses.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.5. **Alternative scenarios for the determinants of adjusted premature mortality** [1]

(Health care resources measured by health care spending)

Variables	1. Full model			2. Model without GDP			3. Lifestyle only (model without GDP & education)			4. Pure macro conditions model		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Constant	11.172***	12.871***	12.244***	9.829***	10.997***	10.475***	9.888***	10.499***	10.099***	11.516***	13.094***	12.424***
Spending	-0.272***	-0.300***	-0.282***	-0.395***	-0.422***	-0.411***	-0.472***	-0.496***	-0.475***	-0.332***	-0.292***	-0.299***
Tobacco	0.063***	0.088***	0.077***	0.066***	0.093***	0.081***	0.109***	0.191***	0.162***			
Alcohol	0.234***	0.082*	0.115***	0.175***	0.073	0.095**	0.150***	-0.052	0.030			
Diet	0.044*	0.001	0.014	0.030	-0.012	-0.001	-0.029	-0.088***	-0.062***			
Pollution	0.169***	0.153***	0.162***	0.151***	0.184***	0.179***	0.112***	0.157***	0.142***	0.174***	0.247***	0.232***
Education	-0.107**	-0.227***	-0.182***	-0.187***	-0.284***	-0.224***				-0.287***	-0.172***	-0.206***
GDP	-0.285***	-0.292***	-0.292***							-0.081	-0.300***	-0.229***
Number of observations	307	307	307	307	307	307	397	397	397	414	414	414
Number of countries	22	22	22	22	22	22	23	23	23	28	28	28

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.6. **Alternative scenarios for the adjusted premature mortality**[1,2]

(Health care resources measured by practitioners)

Variables	1. Full model			2. Model without GDP			3. Lifestyle only (model without GDP & education)			4. Pure macro conditions model		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Constant	11.570***	12.030***	11.90***	7.670***	9.069***	8.634***	5.741***	6.820***	6.303***	12.450***	13.420***	13.290***
Practitioners	-0.089**	-0.062	-0.072*	-0.181***	-0.188***	-0.173***	-0.436***	-0.551***	-0.492***	-0.206***	-0.206***	-0.217***
Tobacco	0.065**	0.186***	0.148***	0.133***	0.156***	0.144***	0.217***	0.333***	0.277***			
Alcohol	0.288***	0.040	0.128**	0.202***	0.098	0.132**	0.089*	-0.123*	-0.026			
Diet	0.088**	0.030	0.055*	0.035	-0.023	-0.009	0.017	-0.107***	-0.063*			
Pollution	0.153***	0.170***	0.162***	0.150***	0.143***	0.141***	0.237***	0.213***	0.248***	0.118***	0.245***	0.184***
Education	-0.250***	-0.297***	-0.262***	-0.449***	-0.579***	-0.541***				-0.423***	-0.272***	-0.376***
GDP	-0.484***	-0.479***	-0.506***							-0.305***	-0.470***	-0.407***
Number of observations	236	237	236	236	237	236	275	276	275	317	318	317
Number of countries	21	21	21	21	21	21	22	22	22	27	27	27

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
2. Practitioners are calculated as the number of practicing physicians and half the numbers of practicing nurses.
   *** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.7. **Alternative scenarios for the determinants of infant mortality**[1]

(Health care resources measured by spending)

Variables	1. Full model	2. Model without GDP	3. Lifestyle only (model without GDP & education)	4. Pure macro conditions model
	Total	Total	Total	Total
Constant	8.516***	6.041***	6.718***	8.438***
Spending	-0.572***	-0.718***	-0.900***	-0.617***
Tobacco	0.077*	0.108**	0.110**	
Alcohol	0.327***	0.243***	0.172**	
Diet	0.044	0.010	-0.065	
Pollution	0.320***	0.340***	0.240***	0.389***
Education	-0.378***	-0.423***		-0.492***
GDP	-0.379***			-0.169**
Number of observations	325	325	424	443
Number of countries	23	23	23	30

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

Table A3.8. **Alternative scenarios for the determinants of infant mortality**[1,2]

(Health care resources measured by practitioners)

Variables	1. Full model	2. Model without GDP	3. Lifestyle only (model without GDP & education)	4. Pure macro conditions model
	Total	Total	Total	Total
Constant	10.580***	3.678***	2.511***	11.000***
Practitioners	-0.442***	-0.530***	-1.420***	-0.459***
Tobacco	0.072	0.197***	0.201***	
Alcohol	0.373***	0.322***	0.132	
Diet	0.118*	-0.012	-0.080	
Pollution	0.188***	0.179***	0.190***	0.217***
Education	-0.498***	-0.928***		-0.609***
GDP	-0.866***			-0.674***
Number of observations	254	254	303	346
Number of countries	22	22	23	29

1. Generalised least square regressions, with country-fixed effects, error terms following a country-specific AR(1) and correction for heteroskedasticity.
2. Practitioners are calculated as the number of practicing physicians and half the numbers of practicing nurses.
*** indicates significance at 1%; ** indicates significance at 5% and * indicates significance at 10%.

Source: OECD calculations.

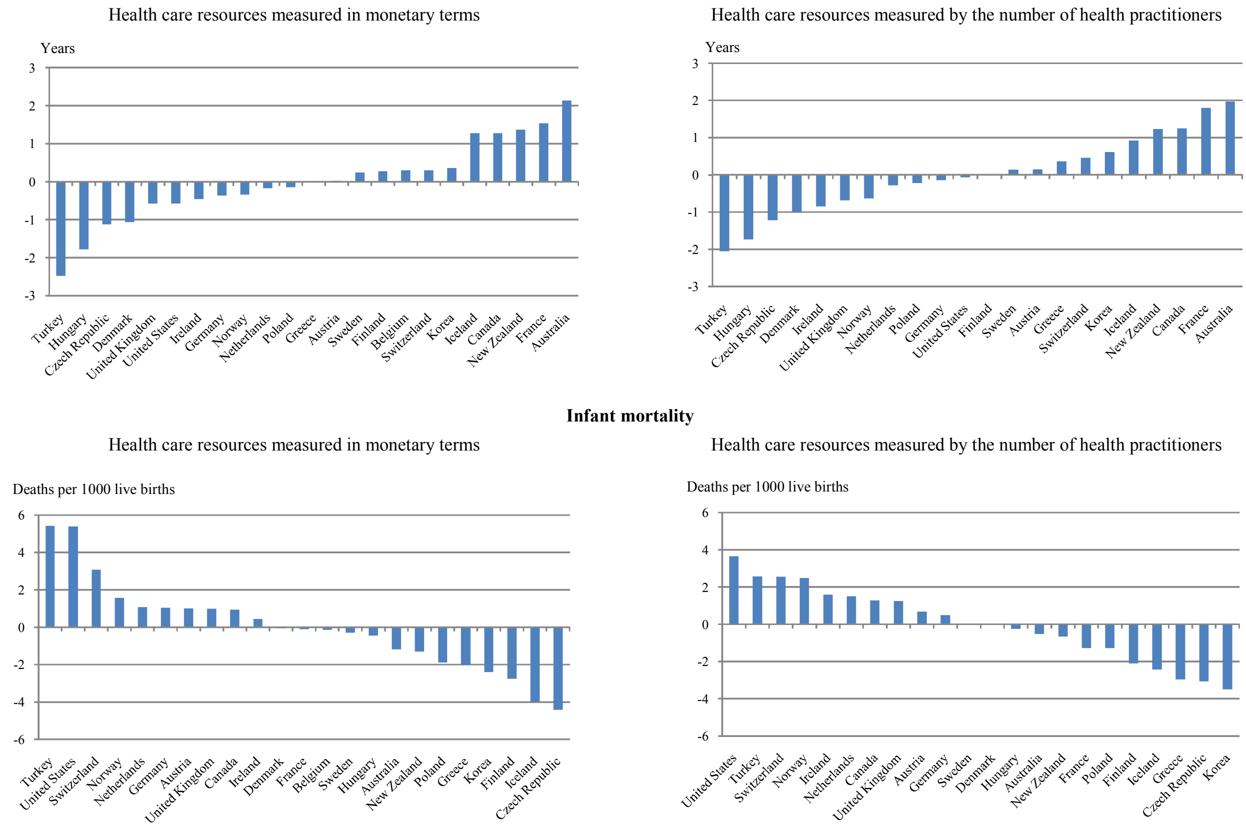
Panel data results: country-specific effects for different health status measures

87. In addition to the regressions for life expectancy presented in the main text, models with other health status measures as the dependant variable have been estimated. Country efficiency rankings derived from these alternative models are shown in Figure A3.2.

Figure A3.2. **Panel data regressions: country-specific effects for selected health status measures**

2003

Female life expectancy at 65



Note: For each status measure, a regression is run. The country-specific effect is computed as the sum of the country-fixed effect and the 2003 residual. Deviations from the OECD average (as presented in this figure) are considered as a proxy for each country relative performance.
Source : OECD calculations.

DEA input-oriented analysis: main results and alternative specification

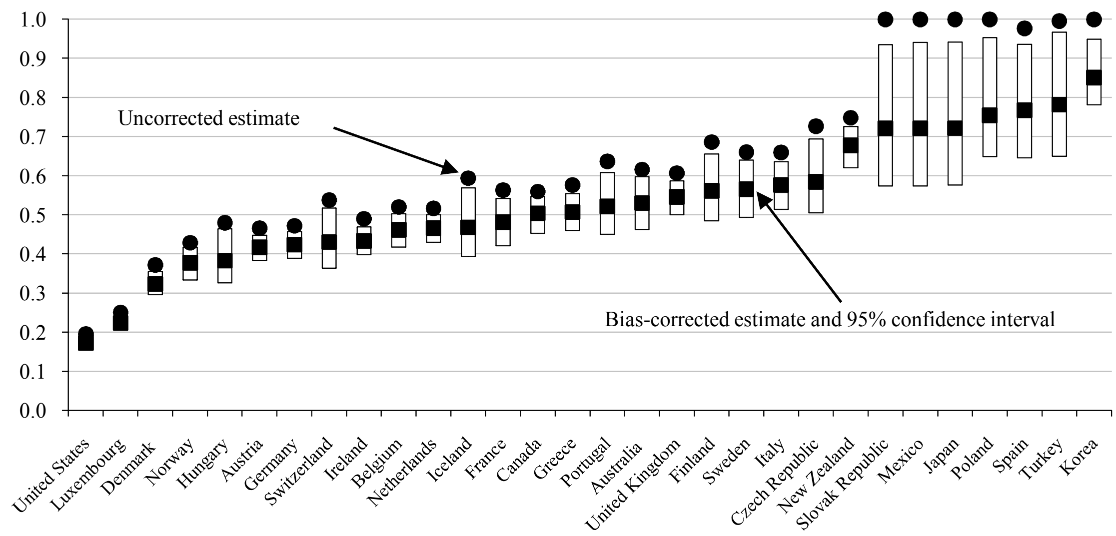
Imposing a constraint on non-discretionary inputs

88. The input-oriented DEA analysis calculates how the level of inputs in a country compares with the most efficient countries with similar health outcomes. Some inputs, however, are non-discretionary (ESCS and Diet). Standard input-oriented DEA programmes are designed to minimise the quantity of *all* inputs to produce a given level of output. In interpreting the potential cuts in inputs which can obtained, while holding health outcome constant, the usual assumption is that each input can be reduced in the same proportion – an irrelevant assumption for non-discretionary inputs. Some economists (Puig-Junoy, 1998; Afonso and St Aubyn, 2006) have proposed a two-steps approach: efficiency scores are first computed with discretionary inputs only; they are regressed on non-discretionary inputs in a second stage. This method is, however, likely to produce biased results when applied to small samples (Simar and Wilson,

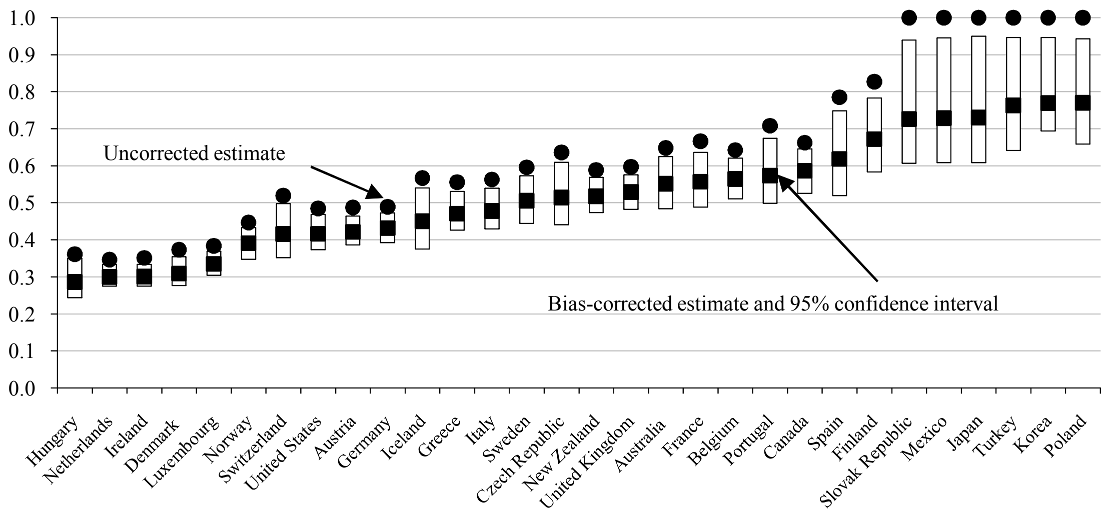
2005). An alternative approach consists of modifying the DEA programme so as to treat non-discretionary inputs as if they were outputs (Retzlaff-Roberts *et al.*, 2003) -- higher levels of ESCS and Diet could justify having lower spending, everything else equal. Input-oriented efficiency scores computed along these lines are reported in Figure A3.3.

Figure A3.3. **DEA: input oriented efficiency scores** (with ESCS)[1]

A. Health care spending (cost efficiency)



B. Health practitioners (technical effciency)



1. DEA performed with one output (life expectancy at birth) and three inputs (health care spending or health practitioners, ESCS, consumption of fruits and vegetables) of which two are exogeneous factors and hence constrained at their actual level.

Source: OECD calculations.

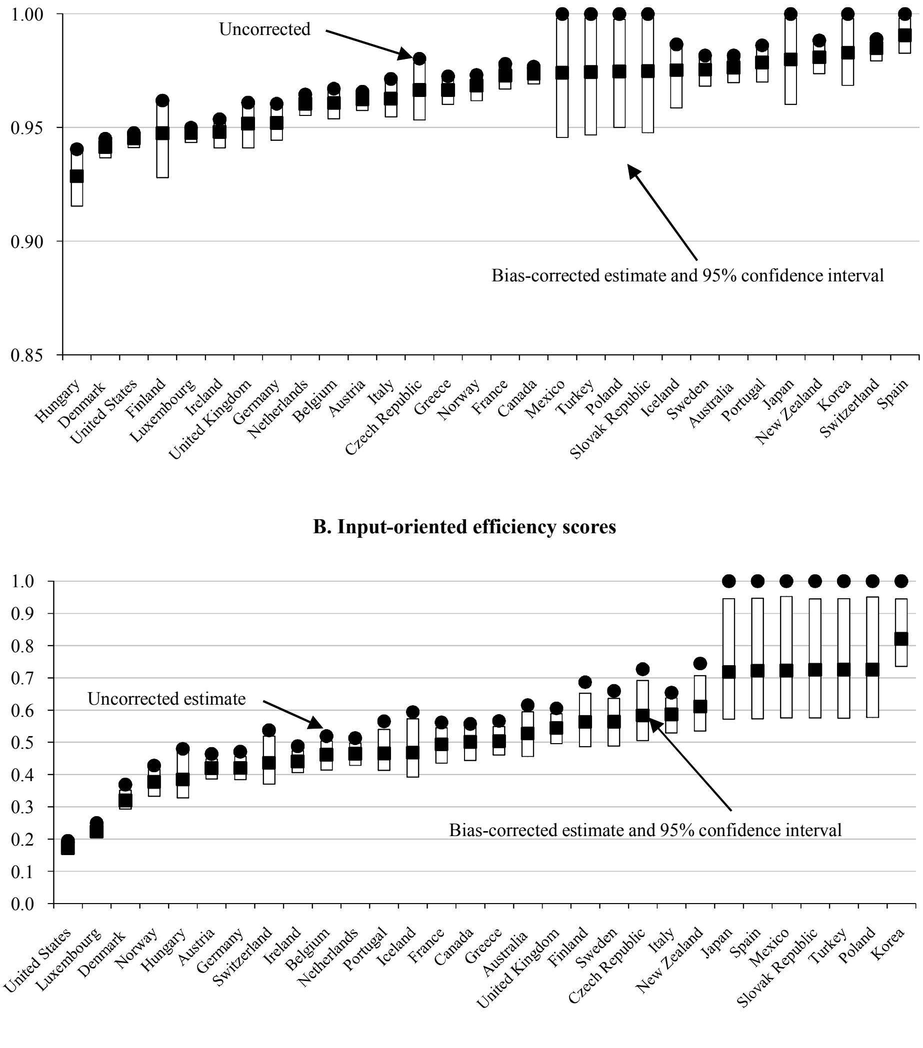
89. This approach suggests that Japan, Korea and Spain are very efficient, both from a cost and technical efficiency perspective. A number of countries among those with the lowest *per capita* income in the OECD are also rated as efficient, but these scores are to be taken with caution given the low number of countries in the region of the frontier where they are situated. At the opposite, costs efficiency is low in the United States, Luxembourg, Denmark and Norway. Technical efficiency is the lowest in Hungary, the Netherlands and Ireland.

Alternative specification: replacing ESCS by GDP

90. Since DEA results tend to be sensitive to the set of inputs included in the analysis, the robustness of results to an alternative specification has been tested. Specifically, the ESCS variable has been replaced by GDP *per capita*. Variations from the main scenario are very limited. Efficiency scores are very similar, with a maximum difference of respectively 1.5 and 6.7 percentage points in the output and input-oriented results. Country rankings are also very close, with the only major differences being for Turkey and New Zealand, which have significantly higher rankings in the output-oriented approach when GDP replaces ESCS.

Figure A3.4. **DEA: Cost efficiency** (with GDP)[1]

A. Output-oriented efficiency scores



1. DEA performed with one output (life expectancy at birth) and three inputs (health care spending, GDP, consumption of fruits and vegetables) of which two are exogeneous factors and hence constrained at their actual level.

Source: OECD calculations.

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