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Health Spending Projections to 2030: New results based on a revised OECD methodology

Luca Lorenzoni,
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HEALTH SPENDING PROJECTIONS TO 2030

New results based on a revised OECD methodology

Luca Lorenzoni*, Alberto Marino*, David Morgan* and Chris James*

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(*) OECD, Directorate for Employment, Labour and Social Affairs, Health Division.

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Abstract

To gain a better understanding of the financial sustainability of health systems, the OECD has produced a new set of health spending projections up to 2030 for all its member countries. Estimates are produced across a range of policy situations. Policy situations analysed include a "base" scenario – estimates of health spending growth in the absence of major policy changes – and a number of alternative scenarios that model the effect on health spending of policies that increase productivity or contribute to better lifestyles; or conversely, ineffective policies that contribute to additional cost pressures on health systems.

Projection results show that in most scenarios, growth in health spending per capita is expected to be slower than historical growth, but still above growth in the economy over the next fifteen years. On average across the OECD, base estimates project health spending to reach 10.2% of Gross Domestic Product (GDP) by 2030, up from 8.8% in 2015. The lower and upper bound of plausible estimates are for health spending to reach between 9.6% and 10.8% of GDP, depending on how successful or otherwise policies are in reining in health spending. Spending by government schemes and compulsory insurance is projected to grow faster than total health spending, with its share of total health spending rising from 74.2% to 77.4% by 2030.

In the base scenario, changes in income account for half of the projected average annual growth in health spending across OECD countries. Demographic effects account for just over a quarter of the projected growth. The remaining growth is accounted for by low relative productivity in the health sector and a time effect that accounts for other unexplained factors, including technological change.

Projection results point to two major policy implications for countries. First, it is not realistic that health expenditure will cease to grow – policymakers will therefore need to plan for at least some increases over time. Second, even if health spending is likely to increase, governments can still have a substantive impact on managing the growth. Proven policy examples include improved laws and regulations on health workforce, pharmaceuticals and new technologies, and effective health promotion and disease prevention strategies.

Résumé

Pour mieux comprendre la viabilité financière des systèmes de santé, l'OCDE a établi un nouvel ensemble de prévisions des dépenses de santé jusqu'en 2030 pour tous les pays membres. Les estimations sont produites pour toute une gamme de situations politiques. Les situations politiques analysées incluent un scénario « de base » - des estimations de la croissance des dépenses de santé en l'absence de changements politiques majeurs - et un certain nombre de scénarios alternatifs modélisant l'effet sur les dépenses de santé des politiques qui accroissent la productivité ou contribuent à de meilleurs modes de vie; ou inversement, des politiques inefficaces qui contribuent à des pressions supplémentaires sur les coûts des systèmes de santé.

Les résultats des projections montrent que, dans la plupart des scénarios, la croissance des dépenses de santé par habitant devrait être plus lente que la croissance historique, tout en restant supérieure à la croissance de l'économie au cours des quinze prochaines années. En moyenne dans les pays de l'OCDE, les estimations de base prévoient que les dépenses de santé atteindront 10.2% du produit intérieur brut (PIB) d'ici 2030, contre 8,8% en 2015. Les limites inférieures et supérieures des estimations plausibles prévoient que les dépenses de santé atteindront entre 9.6% et 10.8% du PIB, selon le succès ou non des politiques de maîtrise des dépenses de santé. Les dépenses des régimes publics et de l'assurance obligatoire devraient augmenter plus rapidement que le total des dépenses de santé, sa part dans le total des dépenses de santé passant de 74.2% à 77.4% d'ici 2030.

Dans le scénario de base, les variations de revenus représentent la moitié de la croissance annuelle moyenne projetée des dépenses de santé dans les pays de l'OCDE. Les effets démographiques représentent un peu plus du quart de la croissance projetée. La croissance restante est imputable à la faible productivité relative du secteur de la santé et à un effet temporel qui prend en compte d'autres facteurs inexpliqués, notamment le changement technologique.

Les résultats des projections font apparaître deux implications politiques majeures pour les pays. Premièrement, il n'est pas réaliste de penser que les dépenses de santé vont cesser de croître - les décideurs devront donc prévoir au moins certaines augmentations au fil du temps. Deuxièmement, même si les dépenses de santé devraient augmenter, les gouvernements peuvent toujours avoir un impact important sur la gestion de la croissance. Les exemples de politiques éprouvées comprennent l'amélioration des lois et des réglementations sur le personnel de santé, les produits pharmaceutiques et les nouvelles technologies, ainsi que des stratégies efficaces de promotion de la santé et de prévention des maladies.

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1. Introduction

1. Across the OECD, health spending has typically outpaced economic growth in recent decades. Such increases in health spending have contributed to improvements in health outcomes and have been an important source of economic growth and jobs. However, the financial sustainability of this upward trend is also a concern, particularly as funding is largely drawn from public sources in most OECD countries.

2. To gain a better understanding of this financial sustainability challenge, the OECD has produced a new set of health spending projections for all its member countries. These build on previous OECD projections, with a revised methodology that models total current health spending and accounts for the latest evidence on key spending drivers.

3. Estimates of health spending up to 2030 are produced for each member country across a range of policy situations. Policy situations analysed include a "base" scenario – estimates of health spending growth in the absence of major policy changes – and a number of alternative scenarios. These alternative scenarios model the effect on health spending of policies that increase productivity or contribute to better lifestyles; or conversely, ineffective policies that contribute to additional cost pressures on health systems.

4. This paper is structured as follows. First, the new health spending projections model is described. Then results to 2030 for all OECD countries and Colombia are presented. A following section discusses policy implications of these results. A final section concludes the paper. An annex describes in details model assumptions and calculation steps.

2. Key drivers of health spending and OECD's new projection model

2.1. Rising incomes, productivity constraints, demographic change and technological progress are key drivers of health spending growth

5. Demand for higher quality and more accessible services for all has driven much of the observed increases in health spending over the last twenty to thirty years. In particular, *rising incomes* have elevated expectations of what health systems should deliver (Chernew and Newhouse, 2012; Baltagi, 2010).

6. However, health spending growth has also been driven by rising costs. *Productivity gains*, whilst achievable, are made more challenging by the labour-intensive nature of the health care sector (Baumol, 1967; 1993). *Demographic change*, particularly in the form of rapidly ageing populations, have affected patterns of morbidity, and consequently spending on health care. The strength of this effect on spending, though, will be moderated if populations age healthily (Breyer and Felder, 2006).

7. *Technological advancement* is also a key driver of health spending (Newhouse, 1992; Cutler, 2004; Smith et al., 2009). Its effect is closely interlinked with each of the other drivers. As a country's wealth increases, there are typically more advances in medical technologies that extend the scope of health services, but at a cost. New technologies influence demographic change by extending life expectancy and changing patterns of morbidity. However, the inefficient use of new technologies may also increase health spending without corresponding improvements in health status (Chandra and Skinner, 2012).

8. Taken together, these drivers have explained much of the historical growth in health spending in OECD countries. At the same time, a range of cost containment policies has been effective at offsetting, at least to some extent, these upward pressures on health spending (Marino et al., 2017).

2.2. New OECD health spending projections produce cross-country comparisons that are transparent in their approach and policy relevant

9. Given the strong predictive power and evidence of the drivers outlined in the previous section in explaining health spending growth – namely rising incomes, constraints to productivity gains, demographic changes and technological advancements – they form the basis of the new OECD projections. In addition, a number of policy scenarios are also analysed, focusing on how to alter health spending trajectories through plausible government interventions focused on these drivers.

10. Central to the development of new OECD health spending projections are three core principles. First, the ability to produce results that allow for reliable cross-country comparisons. This means selecting variables for which data are widely available across OECD countries. Transparency is the second guiding principle. Accordingly, each step of the projection approach is clearly specified, including all major assumptions made. Finally, projections have been devised to be as policy relevant as possible. This is achieved by presenting several alternative scenario which model a range of future developments linked to different types of policy options.

11. Projection results focus on total current[1] health spending[2], with additional results for public health spending[3]. However, the projections framework is designed to allow for disaggregated analyses in the future, such as health spending growth by different types of health care (curative care, long-term care, pharmaceuticals and other types of services), and for different time horizons.

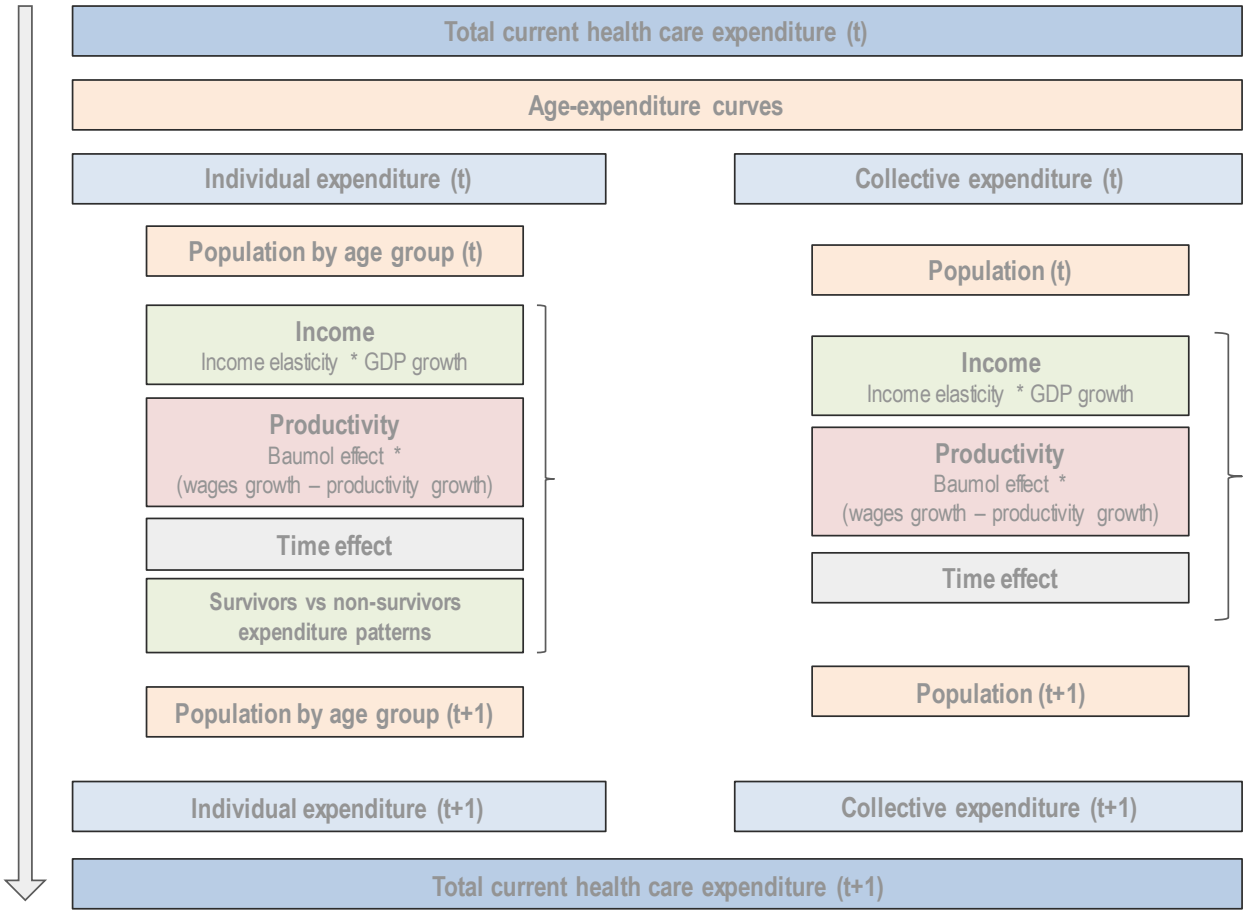
12. Figure 2.1 below illustrates the projections framework, indicating how different drivers are incorporated into the projection model. This framework builds on a previous OECD model (de la Maisonneuve and Oliveira Martins 2013), but also entails a significantly revised approach, in light of the latest evidence on the determinants of health spending.

[1] While capital investment in the health care system (e.g. building, machinery and software) is relevant in the future production of health care services, spending on capital items is not included within the scope of the current model as it refers to a different timing of consumption.

[2] It includes long-term care spending.

[3] For ease of reading, in this paper we refer to spending by government schemes and compulsory health insurance as "public" health spending. 'Public' refers to spending by government and schemes of a mandatory nature – i.e. public in this sense indicates the decree of government regulation or control over the uptake of health care coverage. Therefore, arrangements in the Netherlands, Switzerland and the US which are based on an individual obligation to purchase coverage (through private insurers) are included under 'mandatory' schemes. It is true that such spending in the case of Switzerland and the US is not derived from tax revenues or social contributions, and therefore not considered under government spending. However, the discussions about policy options for governments can still apply to an extent given the government 'control' over mandates, minimum benefits, etc. while for the vast majority of countries there is a direct linkage between 'public' spending and public sources. Ideally, we would want to approach the question of public from the more precise perspective of 'public financing of health expenditure'. This would cover government spending (from tax revenues and other incomes), social contributions and other government funding (e.g. through subsidies for PHI, tax breaks, grants, etc.). We are building this information for a majority of OECD countries. In future iterations of the model this can be used, ultimately enabling a better linkage between health spending and revenue-raising.

Figure 2.1. Model flow of the new OECD health spending projection framework



13. As illustrated in Figure 2.1, the starting point of analysis is to disaggregate health expenditure by five-year age groups, using 'age-expenditure curves' to model differences in average expenditures by age. These allow *demographic effects* to be modelled, projecting the impact on expenditure of changes in the age structure. Age-expenditure curves are country-specific and derived from data available for nine OECD countries on health expenditure by age, with estimates for the remaining 27 OECD countries and Colombia based on similarities in the structure of health expenditure. Annex A details the methodology used to estimate these curves.

14. Age-expenditure curves are used to project individual expenditure (which across the OECD constitutes around 93% of total spending), and not collective expenditure (e.g. disease prevention programmes, etc.). This assumption is made as collective expenditure is generally not driven by yearly changes in the age structure, and therefore does not need to be split across age groups.

15. Importantly, age-expenditure curves are further split into expenditure on survivors and non-survivors. This is because, on average, more health services are needed and

therefore more is spent on an individual close to death[4] (non-survivors) than on the general population (survivors). That is, expenditures are concentrated in the last years or months of life independently of the age at which death occurs. This is commonly referred to as the death-related costs hypothesis (Lubitz and Riley, 1993). It implies that survivors are ageing more healthily (as their expenditure is lower than non-survivors) and morbidity is compressed towards later age groups (since mortality rates, and therefore expenditure, are higher in older age).

16. In the model, death-related costs (DRC) – expenditure by an individual close to death – are assumed to be ten times higher than costs for survivors. This ratio reflects the mid-point of values reported in the literature. This value of ten is then adjusted over time to reflect country-specific gains in life expectancy. Such dynamic DRCs are used as a proxy to model healthy ageing. Box 2.1 discusses the main theories on healthy ageing and their relation to the modelling approach taken in this report.

17. Taken together, the impact of demographic effects on health expenditure therefore comes from: (i) changes in the size and structure of the population; (ii) changes in the share of a country's population being close to death; and (iii) country-specific life expectancy gains over time.

Box 2.1. Theories of healthy ageing

The extent to which people are likely to age more healthily in the future has been widely discussed in the literature. Three general hypotheses have been proposed. The most optimistic is a 'compression of morbidity' hypothesis (Fries, 1980). This posits that as life expectancy increases, healthier lifestyles result in a decrease in the number of years lived in poor health or with a disability. In contrast, the 'expansion of morbidity' hypothesis (Gruenberg, 2005) supposes that all life expectancy gains are added near the end of a person's life when they are assumed to be in ill-health.

Finally, the 'dynamic equilibrium' hypothesis (Manton, 1982) posits that life expectancy increases are equalled by additional years without disability/ill health.

A recent review on healthy ageing hypotheses (Lindgren, 2016) found that trends in high income countries have most often been in accordance with the dynamic equilibrium hypothesis, with some evidence of a compression of morbidity and limited to no evidence of an expansion of morbidity.

The new OECD health spending projection framework is consistent with the dynamic equilibrium hypothesis. It models healthy ageing through dynamic death-related costs which increase over time to reflect gains in life expectancy. This results in a net reduction in expenditure – on average - for survivors, which can be interpreted as a survivor being healthier in the future. In the base scenario, a partial dynamic equilibrium is adopted, whereby 50% of the gains in life expectancy translate into DRC growth across all age groups.

[4] Closeness to death is measured differently across studies. For the purpose of our macro-based projections, the share of non-survivors is measured as the absolute number of people within the population who will die within the calendar year.

18. The impact of income, productivity constraints and time-specific effects on health care expenditure are then estimated through panel regressions run on historical data (1994-2015) for all OECD countries. In terms of the overall model flow, these effects are estimated to increase health spending at all ages, and thus shift age-expenditure curves up. Additional controls for demography and technology are also included, measured by the share of people aged 65 or more in the total population and R&D expenditure in the general economy, respectively. The regression model uses log-differenced data for all variables[5]. The preferred specification uses a one-year lag for income (measured by GDP) and a three-year lag for technology.

19. The *income effect* is measured by the income elasticity of health spending, which captures the percentage change in health expenditure in response to a given percentage change in income. While early studies found income elasticity to be higher than one (health expenditure increasing faster than income), current evidence using international panel data and appropriate regression methods largely finds income elasticity of around 0.7-0.8 for OECD/high-income countries. Evidence generally shows that as countries become richer, income elasticity tends to decrease (Baltagi et al. 2017). Intuitively this means that as countries achieve adequate levels of care and coverage for all, a relatively lower share of income will be allocated to health.

20. In the preferred specification, the estimate for the income elasticity of total health spending is 0.73. For projections, this means a 1% increase in GDP brings about an average 0.73% increase in health spending. It is important to note this does not necessarily imply that health expenditure as a share of GDP will decrease, since the income effect does not factor in growth resulting from all other drivers. For expenditure from public sources, the income elasticity is higher at 0.79.

21. Potential *productivity constraints* are measured by the "Baumol variable", a proxy that captures the impact of lower productivity growth in the health sector relative to other sectors of the economy on health spending. The theory that productivity is inherently different across sectors in the economy was developed by the economist Baumol. He posited that some sectors of the economy are non-progressive, meaning they do not benefit from technological advancements as much as other sectors do. Such sectors, including health and education, do not displace labour at the same rate (or at all) when new technologies are implemented, as compared to progressive sectors of the economy. Indeed, new technologies can have the opposite effect, as they come with increased costs (more specialised training required) or increased volumes (more staff required). The Baumol effect states that as productivity and wages rise together in progressive sectors of the economy, the health sector (being non-progressive) will experience only wage increases in order to keep up with the rest of the economy. Recent literature has shown that the Baumol effect – as captured by the excess wage growth over productivity growth in the total economy – is highly significant in explaining health spending trends (Colombier, 2012, 2016; Hartwig, 2008, 2011).

22. In the preferred specification, our panel regression analysis confirms that a Baumol effect only partly affects the health care sector (a statistically significant coefficient of 0.265) as some parts of the health care system, such as long-term care, are certainly more likely to be affected by the Baumol cost disease than other parts, such as surgery

[5] Instantaneous growth form is commonly used for macro models of health expenditure drivers in order to correct for unit roots and co-integration issues. Annex A provides a more detailed overview of the regression methods used for estimating model parameters.

23. It has to be noted that across OECD countries the excess wage growth in real terms over productivity growth in real terms in the total economy is close to zero on average (-0.0013 in our panel dataset), with several countries showing slightly negative values across the panel. This means that we are unable to use the Baumol variable itself for projections purposes, since we cannot reasonably expect this differential to be positive. Therefore, we adopt Colombier's method (2017), using historical country-specific average growth in wages in real terms in the overall economy as our reference projection series, and multiply it by the coefficient estimated in the panel regression for the Baumol variable, which captures the differential in productivity growth between the total economy and the health sector. This implies a 1% increase in wage growth in real terms in the total economy is translated into a 0.265% increase in health spending, all else equal. For expenditure from public sources, the coefficient estimated for the Baumol variable is higher at 0.309.

24. Lastly, *technological progress* in the health sector is estimated. Technological progress takes different forms – product, knowledge or process innovation – and represents the most complex driver of health care expenditure to model (Chernew and Newhouse, 2011). The challenge technology poses as a driver is twofold: first, endogenous interactions with other drivers of spending are large. Technology affects demographic change, shapes productivity and to some extent reflects consumer demand as incomes rise. Second, such interactions, and indeed technology on its own, is difficult to account for at the macro level: proxies for technology are both scarce and inefficient, particularly for international panels.

25. Two proxies for technological progress are used in the regression model. First, expenditure growth on research and development (R&D) is included. This proxy variable was not significant in regressions for either total or public health spending – in line with the literature – but it did significantly affect other drivers in some of the specifications. Second, time-specific fixed effects are included. This captures systematic growth that is not taken into account from all other parameters within the model, reflecting in part technological progress. The resulting variable is a year-specific growth for all years in the panel, which are subsequently averaged using a linear weighting that gives more weight to years closer to the base year of the projection and less weight to years further away, using 2008 as base year (weight = 1). The coefficient for this time-specific effect is 0.004, implying a 0.4% increase in health spending for each year, all else equal. For expenditure from public sources, a 0.005 coefficient is estimated.

26. The impact of technological progress on health spending is therefore estimated though the time-specific coefficient, while also acknowledging that some of its effect might be endogenously captured by the coefficients for demography, income and Baumol.

27. This modelling methodology is used for both total and current health spending. The same general approach is used to project public health spending. The only difference is that main difference between the two models lies in the different baseline expenditure and driver coefficients (estimated through regressions on public spending) applied to projection series.

2.3. Base projections of health spending growth are benchmarked against a number of scenarios reflecting plausible policy interventions

28. To maximise the relevance of results for policy makers, a number of scenarios are explored. First, health spending projections up to 2030 are modelled for a "base" scenario. This estimates health spending in the absence of any major policy change. Empirically, this scenario uses estimates based on the preferred specification for the income elasticity,

productivity constraint and time effects. Finally, demographic effects reflect predictions of longevity gains and the evolving demographic structure of the population, also accounting for changes in health status (through dynamic DRCs, whereby half of the further years of life expectancy translate into higher DRCs over time and therefore lower health care expenditure for survivors relative to non-survivors).

29. Four alternative scenarios have been designed as a comparison to this base scenario. These scenarios estimate the effect on health spending of policies which increase productivity and contribute to better lifestyles; and conversely, policies that could result in additional cost pressures on health systems.

30. The first of these scenarios is an "enhanced productivity" scenario, where significant productivity gains in the health sector are achieved over time. Empirically, assigning a linearly declining Baumol coefficient (from 0.265 in 2015 to 0.1 by 2030 reflects this scenario, the assumption being that productivity gains in the general economy are also partially realised in the health sector. Harnessing new technologies through a better use of HTAs, task-shifting and increased generics uptake are some policy examples that best reflect this scenario.

31. As a counterpoint, a "low productivity" scenario is also modelled, where policies are less effective in strengthening productivity. Empirically this is reflected through a stronger Baumol effect (a coefficient of 0.39 instead of 0.265 consistent with other estimates from the literature, as discussed in Marino et al., 2017).

32. Third is a "full cost control" scenario. This estimates the maximum feasible extent to which effective cost containment policies can offset health spending drivers. It assigns a linearly declining value to the Baumol coefficient from 0.265 to 0.1 (as in the "enhanced productivity" scenario), and assumes that all life expectancy gains translate into higher DRCs over time and therefore lower health care expenditure for survivors compared to the "base" scenario. It also assumes that income elasticity will gradually decline from 0.73 to 0.7 by 2030 – reflecting that as countries become richer, health systems become more efficient and health outcomes improve.

33. Finally, a "cost pressure" scenario is estimated. Here, ineffective cost containment policies, combined with rising expectations on health care, lead to the introduction of expensive new technologies, with insufficient consideration of their cost-effectiveness. While in this scenario quality of care may increase, such gains will come with considerable cost pressures. Empirically, this is reflected by a higher income elasticity and Baumol productivity constraint, of 0.85 and 0.39 respectively, each reflecting the upper bounds of our regression estimates.

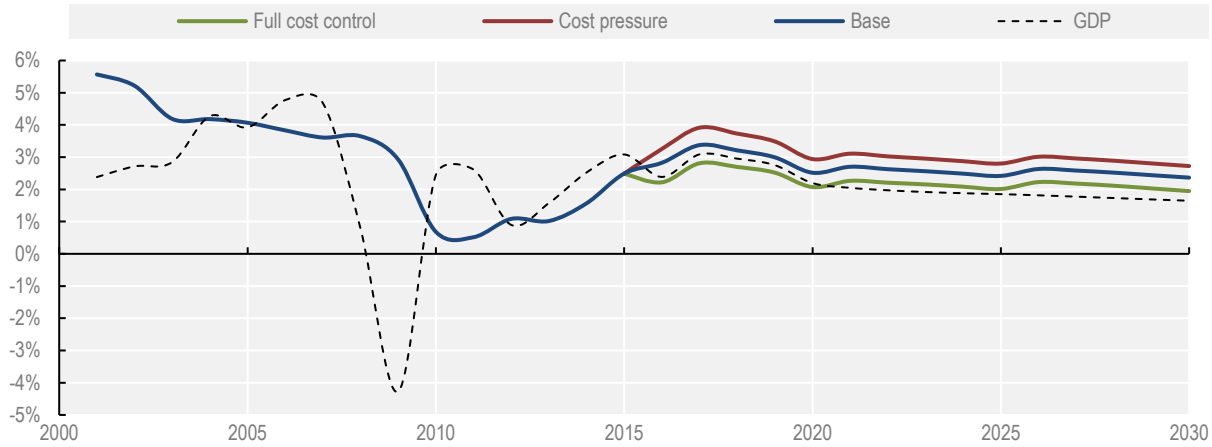
3. Health spending projections to 2030 for all OECD countries

3.1. Across the OECD, health spending per capita is projected to grow more rapidly than GDP per capita, but at a slightly slower rate than observed for 2000-2015

34. Health spending per capita across the OECD is projected to grow at an average annual rate of 2.7% for 2015-2030 for the base scenario (all results in constant prices, accounting for inflationary effects). This compares with 2.2% for the 'full cost control' and 3.1% for the 'cost pressure' scenarios (Figure 3.1). With an average historical annual growth of 3% for the period 2000-2015[6], base projections indicate a slight slowdown in health spending growth compared to the past.

35. Nevertheless, growth in health spending is likely to be significantly higher than GDP growth. Health spending generally trends GDP growth in terms of its shape, but other spending drivers push it above GDP growth, particularly in the 'cost pressure' scenario. This partial relationship between health spending and GDP is consistent with previous OECD analysis of historical spending, which found that cyclical fluctuations in the economy accounted for less than half of the slowdown in health spending during the 2005-2013 period, with the remainder accounted for by policy effects (Lorenzoni et al., 2017).

Figure 3.1. Growth in health spending per capita and GDP per capita, historical (2001-2015) and projected (2016-2030)



Source: OECD Health Statistics Database (2018); Guillemette and Turner (2018).

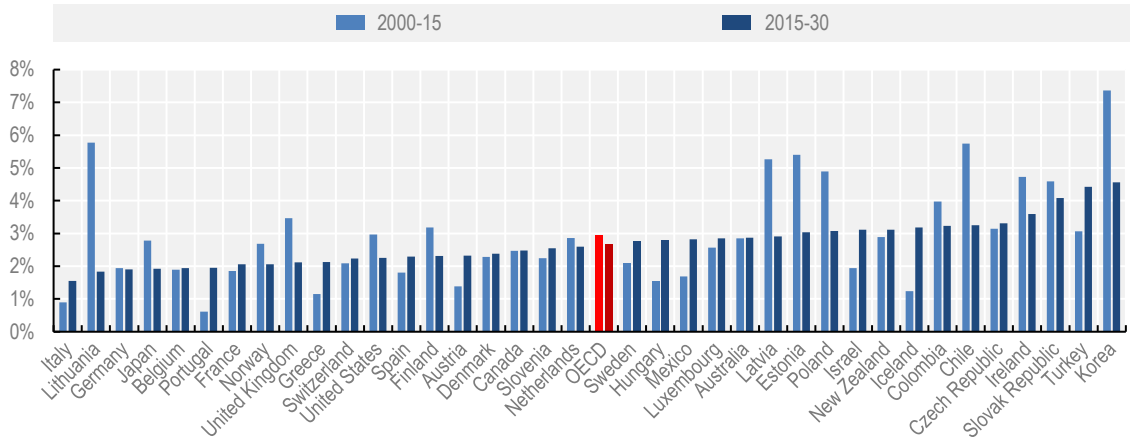
3.2. Projected annual growth in health spending per capita ranges from 1.5% in Italy to 4.5% in the Republic of Korea

36. Health spending per capita for 2015-30 is projected to grow above 4% per year in the Slovak Republic, Turkey and the Republic of Korea (Figure 3.2, Panel A). These are all countries with relatively high GDP growth forecasts over the period studied. In contrast, the projected growth in Portugal, Belgium, Japan, Germany, Lithuania and Italy is less than 2%.

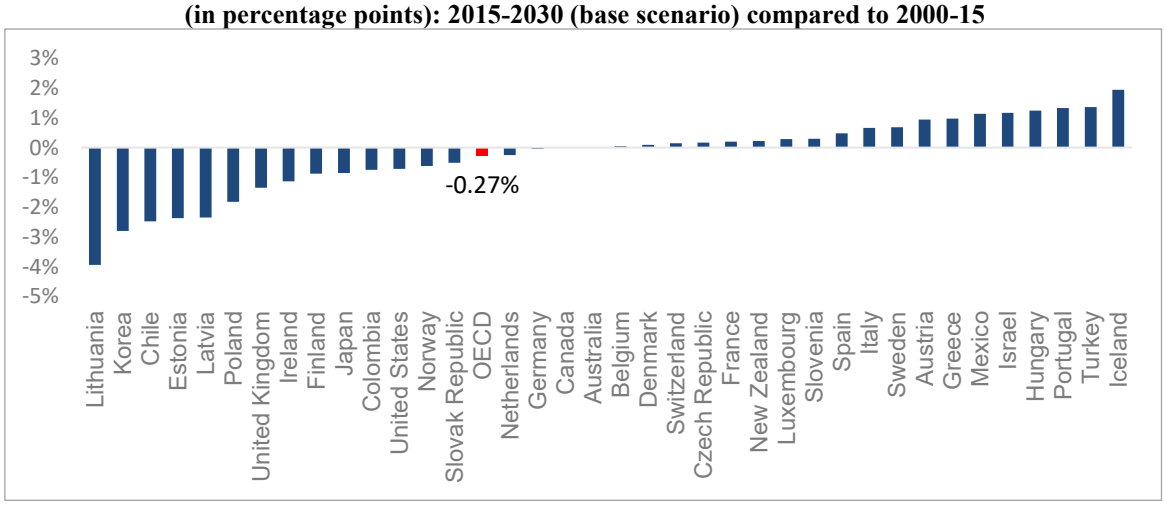
[6] Historical annual growth exclude countries with breaks in spending data for any particular year.

37. In 20 out of 37 countries, growth projections for 2015-30 are within a range of around ±1 percentage points' growth compared to 2000-15 (Figure 3.2, Panel B). In six countries – Iceland, Hungary, Mexico, Israel, Portugal and Turkey – per capita growth is projected to be more than 1 percentage point higher than observed for 2000-2015. Most of these countries experienced a slowdown in health care expenditure growth in the aftermath of the 2008 global economic and financial crisis. In contrast, in Lithuania, the Republic of Korea, Chile, Latvia and Estonia, growth rates are projected to be over two percentage points lower than historical rates. These countries reported some of the highest growth rates in health spending per capita from 2000 to 2015 (Figure 3.2, panel A).

Figure 3.2. Country-specific growth in health spending per capita
Panel A: Average yearly growth, 2000-15 and 2015-30 (base scenario)



Panel B: Country-specific differential of average yearly growth in health spending per capita (in percentage points): 2015-2030 (base scenario) compared to 2000-15



3.3. Health spending is likely to account for an increasing share of GDP in all OECD countries

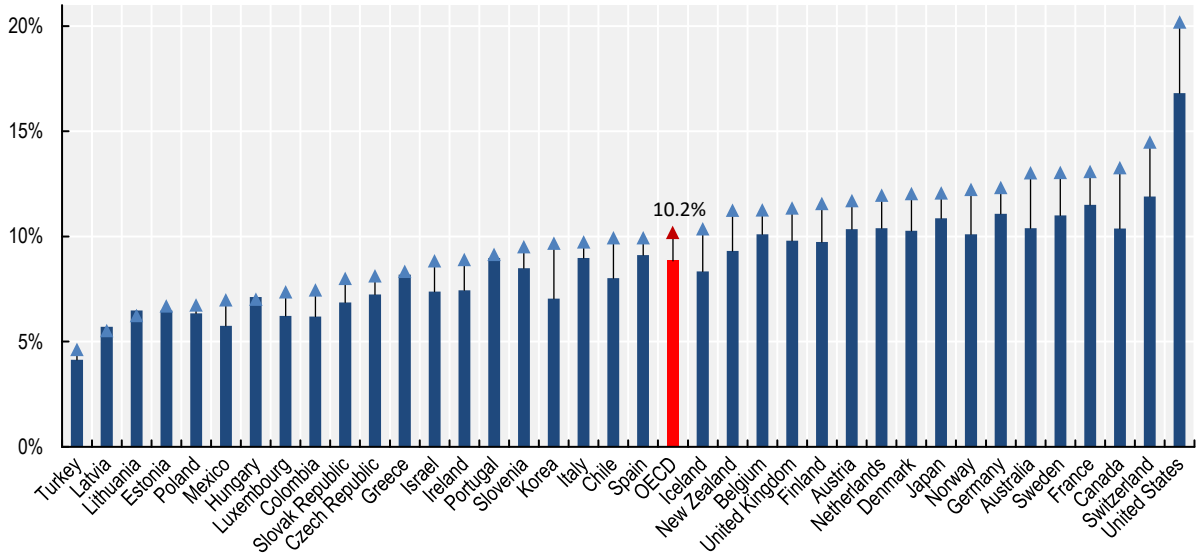
38. On average across the OECD, health spending is projected to reach 10.2% of GDP by 2030, compared to 8.8% in 2015 (**Figure 3.3**, Panel A). Health spending is expected to slightly decrease as a share of GDP in Latvia, Hungary and Lithuania as a result of a large projected decrease in population numbers. Most countries will experience, in the base

scenario, moderate increases in health spending as a share of GDP, with increases of more than three percentage points projected in the United States mainly due to increases in population and change in its structure, and expansion of coverage.

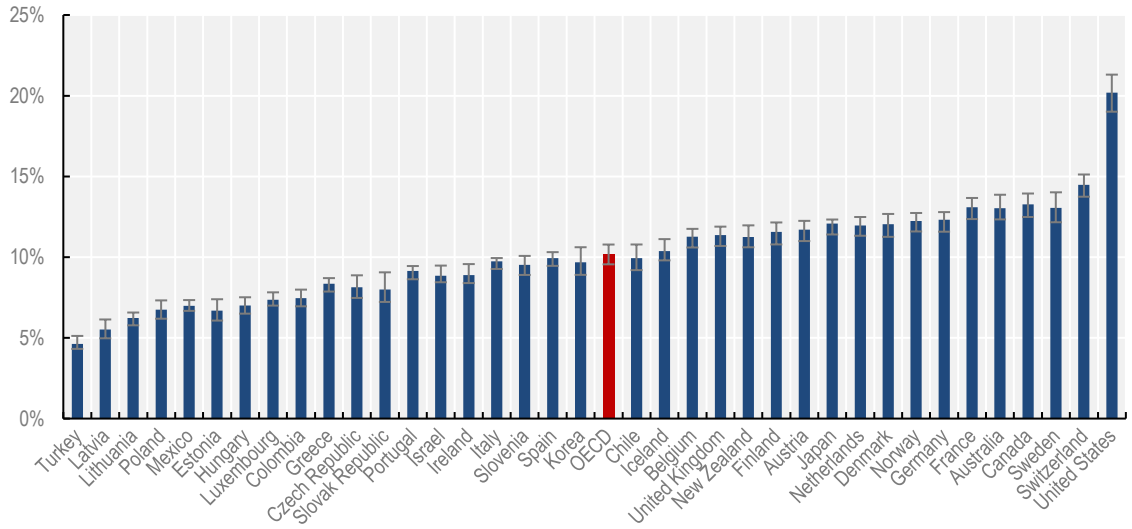
39. Under the 'cost pressure' scenario, health spending is expected to reach 10.8% of GDP (compared to 10.2% in the base scenario). At the lower end, in the 'full cost control' scenario, health spending as a share of GDP is projected to reach 9.6%, still a slight increase on its 8.8% share of GDP in 2015 (**Figure 3.3**, panel B).

Figure 3.3. Health spending as a share of GDP by country

Panel A: 2015 and 2030 (base scenario)



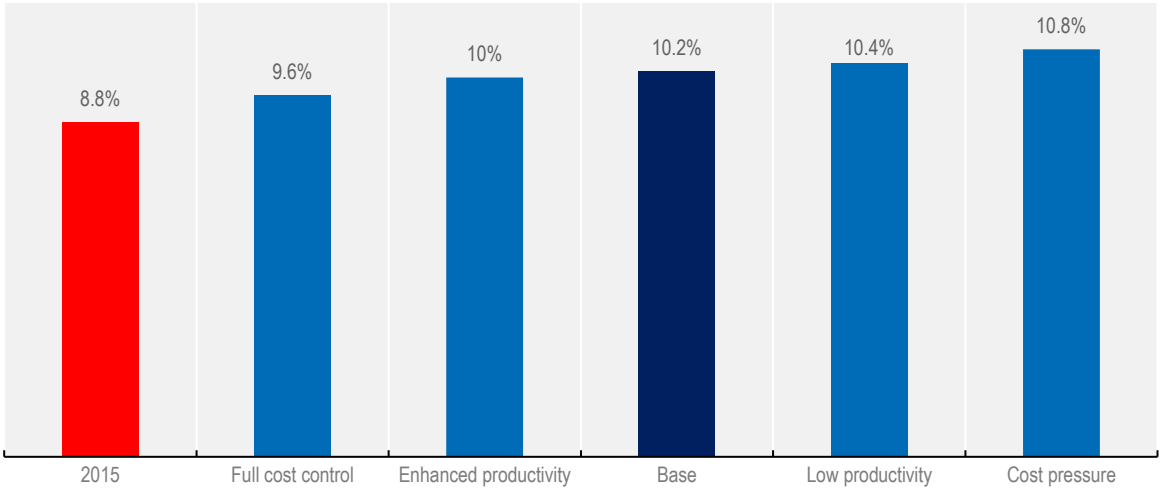
Panel B: Full cost control and cost pressure scenarios compared to base scenario by country, 2030



40. Looking at the other scenarios for the OECD as a whole, in the 'enhanced productivity' scenario, health spending as a share of GDP is projected to increase by 1.2 percentage point (to 10% of GDP) by 2030, compared to 1.4 percentage points in the 'base scenario', (Figure 3.4). By contrast, in the 'low productivity' scenario, health spending as

a share of GDP is projected to increase by a further 0.2 percentage points than in the 'base' scenario.

Figure 3.4. Health spending as a share of GDP, full range of scenarios. OECD average



41. **Table 3.1** below shows the coefficient values for each driver, in each projection scenario.

Table 3.1. Parameter values for scenario analysis

	Income	Productivity constraints (Baumol)	Healthy ageing (death-related costs)	Healthy ageing (dynamic equilibrium)	Time-specific effects
Base scenario	**0.73**	**0.265**	**10**	**0.5**	**0.004**
Full cost control	0.73 – 0.7	0.265 – 0.1	10	1	0.004
Enhanced productivity	0.73	0.265 – 0.1	10	0.5	0.004
Low productivity	0.73	0.39	10	0.5	0.004
Cost pressure	0.85	0.39	10	0.5	0.004

42. Full country-specific scenario analysis of health spending as a share of GDP is presented in Table 3.2. In Chile, Slovak Republic, Republic of Korea, Sweden and the United States, the difference between the "cost pressure" and the "full cost control" scenario is greater than 1.5 percentage points. In these countries, changes in policies might have a larger impact on changing future trajectories on health spending. In contrast, in Italy and Mexico the difference between these scenarios is of 0.7 percentage points.

Table 3.2. Health spending as a share of GDP by country, 2015 and 2030 (all scenarios)

	2015	Full cost control	Enhanced productivity	Base scenario	Low productivity	Cost pressure
Australia	10.4%	12.3%	12.9%	13.0%	13.3%	13.9%
Austria	10.3%	11.0%	11.6%	11.7%	11.9%	12.2%
Belgium	10.1%	10.6%	11.2%	11.3%	11.4%	11.8%
Canada	10.4%	12.5%	13.1%	13.3%	13.5%	13.9%
Chile	8.0%	9.2%	9.7%	9.9%	10.3%	10.8%
Colombia	6.2%	7.0%	7.3%	7.5%	7.6%	8.0%
Czech Republic	7.2%	7.5%	7.9%	8.1%	8.5%	8.9%
Denmark	10.3%	11.3%	11.9%	12.0%	12.3%	12.7%
Estonia	6.5%	6.1%	6.4%	6.7%	7.1%	7.4%
Finland	9.7%	10.8%	11.4%	11.6%	11.8%	12.1%
France	11.5%	12.4%	12.9%	13.1%	13.3%	13.7%
Germany	11.1%	11.6%	12.2%	12.3%	12.5%	12.8%
Greece	8.2%	7.9%	8.3%	8.3%	8.4%	8.7%
Hungary	7.1%	6.5%	6.9%	7.0%	7.2%	7.5%
Iceland	8.3%	9.8%	10.2%	10.4%	10.7%	11.1%
Ireland	7.4%	8.4%	8.7%	8.9%	9.1%	9.6%
Israel	7.4%	8.4%	8.8%	8.8%	8.9%	9.5%
Italy	9.0%	9.3%	9.7%	9.7%	9.8%	9.9%
Japan	10.9%	11.4%	12.0%	12.1%	12.1%	12.3%
Korea	7.0%	8.9%	9.4%	9.7%	10.1%	10.6%
Latvia	5.7%	5.0%	5.3%	5.5%	5.9%	6.1%
Lithuania	6.5%	5.8%	6.1%	6.2%	6.4%	6.6%
Luxembourg	6.2%	7.0%	7.3%	7.4%	7.4%	7.8%
Mexico	5.8%	6.7%	7.0%	7.0%	7.0%	7.3%
Netherlands	10.4%	11.3%	11.9%	12.0%	12.1%	12.5%
New Zealand	9.3%	10.6%	11.1%	11.3%	11.4%	12.0%
Norway	10.1%	11.6%	12.1%	12.2%	12.4%	12.7%
Poland	6.3%	6.2%	6.6%	6.7%	7.0%	7.3%
Portugal	9.0%	8.6%	9.1%	9.1%	9.2%	9.4%
Slovak Republic	6.9%	7.2%	7.6%	8.0%	8.6%	9.1%
Slovenia	8.5%	8.9%	9.3%	9.5%	9.8%	10.1%
Spain	9.1%	9.5%	9.9%	9.9%	10.0%	10.3%
Sweden	11.0%	12.2%	12.8%	13.0%	13.5%	14.0%
Switzerland	11.9%	13.7%	14.3%	14.5%	14.7%	15.1%
Turkey	4.1%	4.3%	4.6%	4.6%	4.7%	5.1%
United Kingdom	9.8%	10.7%	11.2%	11.4%	11.6%	11.9%
United States	16.8%	19.0%	19.9%	20.2%	20.7%	21.3%
OECD	**8.8%**	**9.6%**	**10.0%**	**10.2%**	**10.4%**	**10.8%**

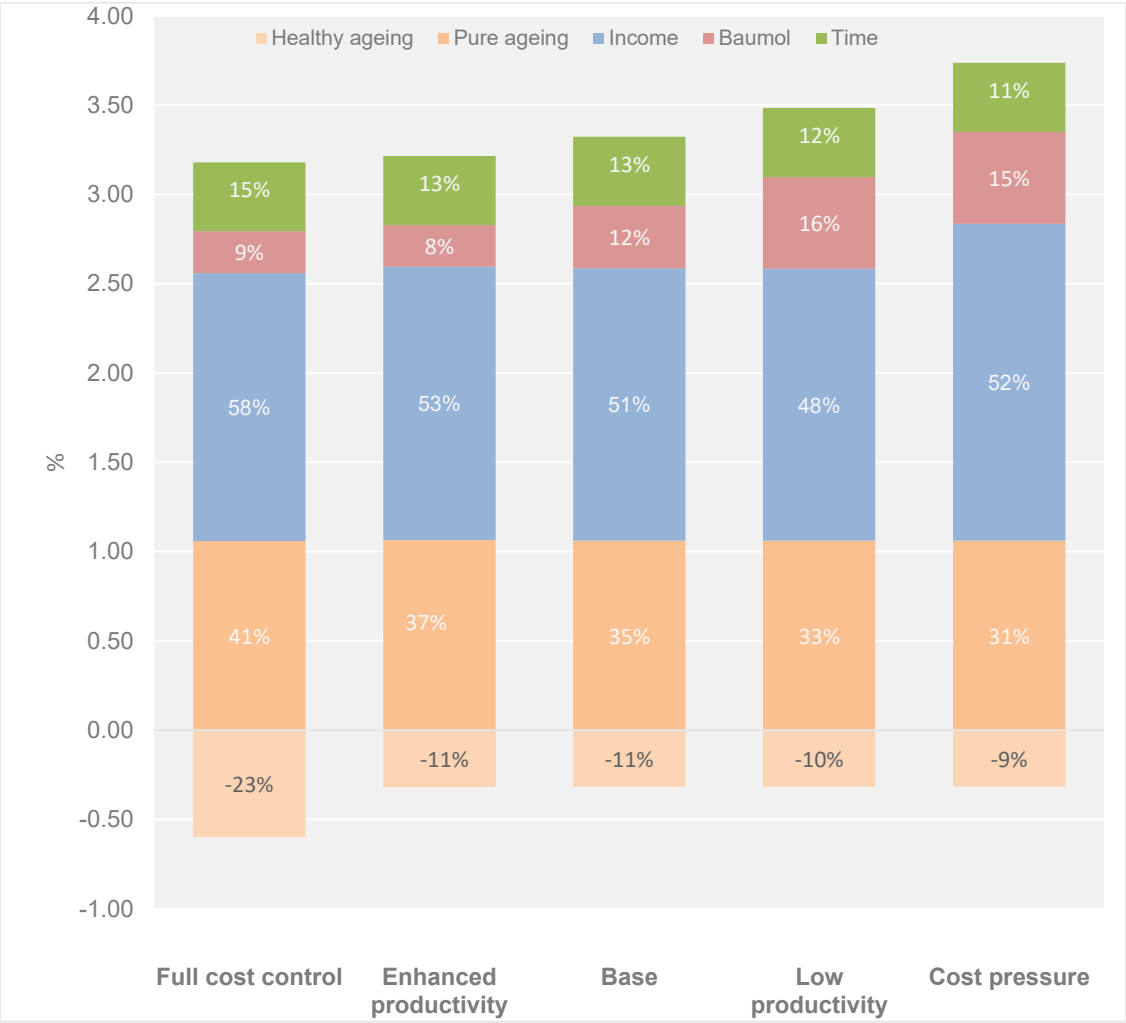
Note: Health spending data in 2015 for Australia includes an upward adjustment of 11.5%, to take into account reporting issues in the amount of spending in long-term care. The baseline projection year in Ireland is 2016 to avoid issues with GDP growth in 2015 (because of a large break in the series).

3.4. Income is the main driver of spending growth, accounting for about half of the projected growth in health spending, with demographic effects accounting for one quarter of the growth

43. In the base scenario, the demographic effect increases health spending by 0.7% per year, on average across the OECD. This amounts to a quarter of overall projected growth (Figure 3.5). Note that the demographic effect comprises a "pure age" effect of 1.1% growth. This is moderated by a degree of compression of morbidity which decreases spending growth by 0.3% (modelled through dynamic DRCs). Income is the most important driver, increasing growth by 1.5% - equivalent to half of annual health spending growth. Productivity constraints (the Baumol effect) increase annual health spending by 0.4%, amounting to about one eighth of overall spending growth. Time-specific effects also increase health spending by an average of 0.4% per year.

44. Alternative policy scenarios illustrate differential impacts spending drivers can have on health spending. For example, productivity constraints increase annual health spending by 0.5% in the 'low productivity' and 'cost pressure' scenarios, equivalent to around one sixth of overall spending growth. A greater degree of healthy ageing means that the demographic effect is smaller in the 'full cost control' scenario, (0.5% rather than 0.7%). The "income" effect is most dominant in the full cost control scenario, accounting for 58% of overall spending growth. Note that sensitivity analysis on the value used for death-related costs and associated healthy ageing assumptions are reported in Box 3.2.

Figure 3.5. Contribution of key drivers to average annual health spending growth to 2030 by scenario



Note: the relative contribution of each driver to growth in reported in percentage within each bar.

45. Analysing the impact of drivers on spending on a country-by-country basis provides further insights (Figure 3.6). Note that in this chart, the effects of pure ageing and dynamic death-related costs are grouped into a single demographic effect.

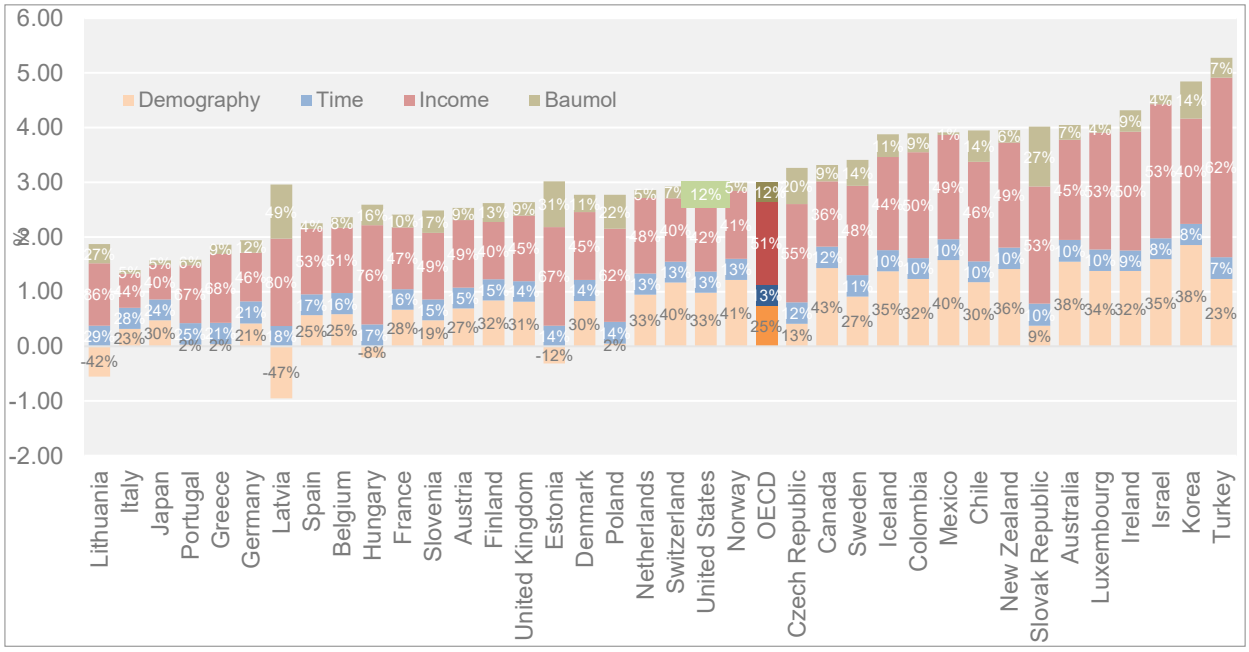
46. Income effects account for more than 2% average annual growth in the Slovak Republic, Ireland, Luxembourg, Israel and Turkey, whereas it accounts for less than 1% growth in Germany, Italy and Japan. Countries with the highest levels of forecast GDP growth exhibit the largest income effects in absolute terms, but the relative share of the income effect is naturally dependent on the magnitude of all other effects in any given country.

47. The Baumol effect, which measures the effect of wages and productivity growth in the economy, is largest and accounts for more than 1% growth in Estonia, Latvia and the Slovak Republic. In contrast, Italy, Japan and Mexico show effects of 0.1% growth or lower. Countries showing a large Baumol effect have experienced wage growth

substantially in excess of productivity growth in the general economy – implying that a larger share of health expenditure would need to be allocated to wages in the health sector so to be on par with wages in the general economy.

48. Demographic effects are largest in the Republic of Korea, Mexico, Israel and Australia – all countries with an absolute growth of 1.5% or more. In contrast, Portugal, Greece and Poland all have small demographic effects of less than 0.1% growth. Moreover, in Lithuania, Latvia, Hungary and Estonia demographic change has a negative effect on spending. This is largely explained by projected decreases in population numbers in these four countries.

Figure 3.6. Contribution of key drivers to average annual health spending growth to 2030 by country. Base scenario



Note: "Demography" sums "pure age" and "healthy ageing" (dynamic death-related costs) effects. The relative contribution of each driver to growth in reported in percentage within each bar.

Box 3.1. Sensitivity analysis for death-related costs

The assumption on death-related costs for the base scenario reflects a mid-point estimate based on a subset of the literature, and is therefore more sensitive to changes, since the estimate of the cost ratio between survivors and non-survivors varies greatly across studies. Figure 3.7 below shows health expenditure as a share of GDP across a range of assumptions for DRCs. The two lines represent our complementary assumption on the dynamic shift of death-related costs over time based on life expectancy gains in each country.

In our base scenario, we assume a starting death-related cost of 10, with 50% of the life expectancy gains translating dynamically into higher death-related costs. Intuitively, this

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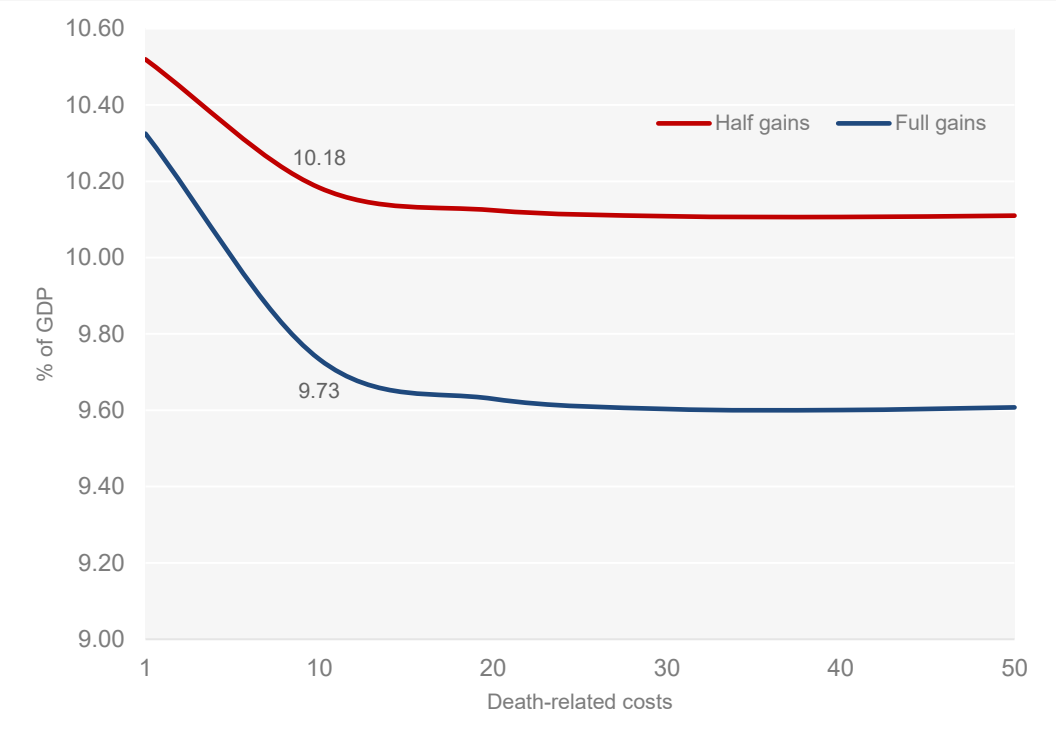
assumption shifts relative expenditure towards later years of life, therefore modelling what the literature refers to as a moderate compression of morbidity hypothesis.

Figure 3.7. Death-related costs sensitivity analysis, base scenario, 2030



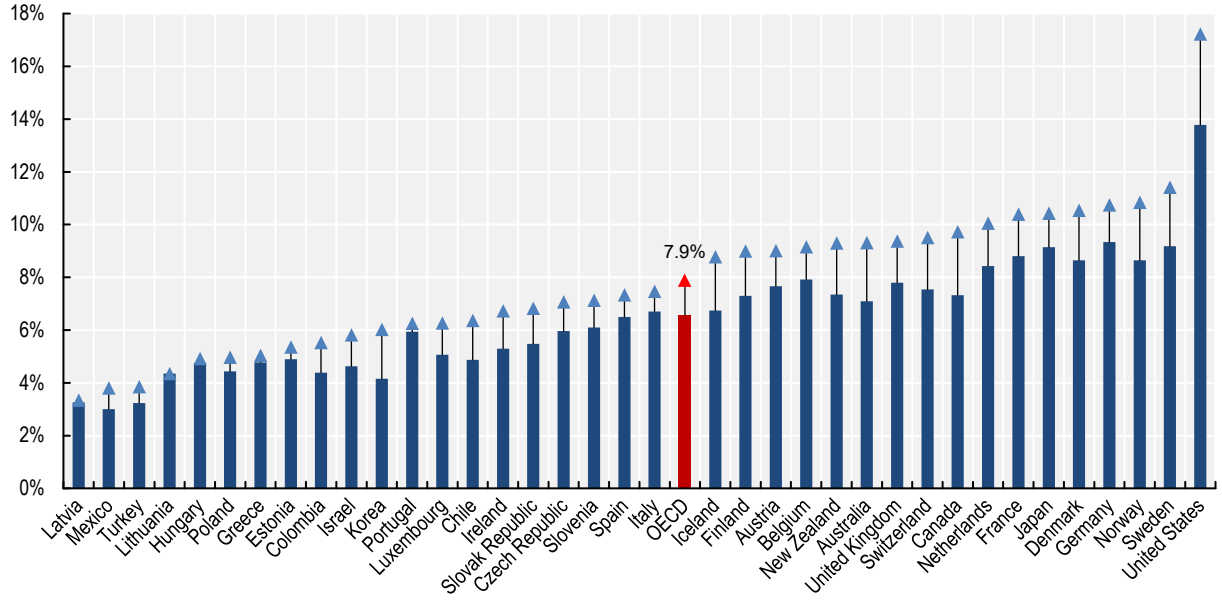
As can be seen from the figure, the share of health spending on GDP remains stable as the value of the base death-related increases over 10 under both half and full life expectancy gains assumptions. Our preferred plausibility range, that is DRCs between 10 and 40, shows a change in HCE as a share of GDP of 0.07 percentage points for half gains (from 10.18% to 10.11%), and 0.13 percentage points for full gains (from 9.73% to 9.6%). This should be interpreted as uncertainty of around 0.1 percentage points of GDP linked to DRC assumptions in the base scenario projections.

3.5. Growth in public health spending largely mirrors total health spending

49. Across the OECD, public health spending as a share of GDP is projected to grow from 6.6% in 2015 to 7.9% in 2030 (Figure 3.8). This reflects an annual per capita growth rate of 3%, compared to 2.7% for total health spending. Increases are expected to be largest in Turkey, the Republic of Korea and Slovak Republic.

50. The share of public health spending over total health spending is projected to increase to 77.4% in 2030, from 74.2% in 2015, across the OECD. This increase of 3.2 percentage points is higher than historical trends at 2.2 percentage points from 2000-2015. These results on public spending are broadly comparable with other international cross-country analyses (see Box 3.2 for further details).

Figure 3.8. Public health spending as a share of GDP by country, 2015 and 2030. Base scenario



Box 3.2. Main differences between the results of this project and other cross-country analyses of health spending projections

Projections shown in this paper build on the methodology employed in previous OECD studies (de la Maisonneuve and Oliveira Martins 2013). Other recent efforts to project expenditure for international panels include the 2018 Ageing Report by the European Commission. These studies present important methodological differences that should be recognised in order to make sound comparisons of results.

The most notable difference is the focus in this paper on total current health spending rather than public expenditure, though estimates of public health spending are also reported. Compared with previous OECD projections, the other main differences are a shorter time window (these projections are only up to 2030); longer and updated time series for all regression variables and input variables for projections (i.e. GDP forecasts, population and mortality forecasts); the impact of the Baumol effect on health care as a whole (instead of only for long-term care), the use of different models for individual versus collective expenditure; and avoiding the use of a residual approach to estimate the impact of technological changes on health spending.

Compared to the Ageing Report of the European Commission (2018), the main difference is that the Ageing Report model projects public health spending by individual drivers rather than measuring overall impact. This methodology partly avoids endogeneity issues, but could also result in individual drivers picking up effects from other drivers, and therefore may result in an overestimation when expenditure by driver is summed.

Both studies share similarities in terms of the drivers used for the analysis, the assumptions taken and the cohort approach used to project health spending, even though methodologies used to construct and project the drivers differ in some cases (e.g. Baumol). Therefore, projections for public health spending from our model should be broadly comparable, both in terms of the methodological assumptions for the drivers and the scenarios used for sensitivity analysis (i.e. degree of healthy ageing, death-related costs, income elasticity, etc.).

Compared to the findings for public health spending reported in this paper (1.3 percentage points growth as a share of GDP), the previous OECD model is generally less conservative, with projections of 1.6 to 2 percentage points growth of health spending as a share of GDP in 2030 across OECD countries. Findings from the Ageing Report, show increases that range broadly from 1.1 to 2.9 percentage points of expenditure in 2070 across EU countries. Comparing the 23 EU members which are also OECD members, our projections show an increase of 1.1 percentage points of health spending as a share of GDP to 2030 (from 6.5% to 7.6%). This is close to figures from the Ageing Report: assuming a linear increase of expenditure beyond 2030 (likely to be an overestimation, and therefore an upper bound), our projections would show an increase of 2.8% in 2060 for these countries.

The Global Burden of Disease Health Financing Collaborator Network (2017) have also produced projections of future spending for a wider group of countries. These results, though, are less directly comparable, as no disaggregation of health spending by age group is used.

4. Policy implications

51. Projection results show that across all scenarios, health spending will increase – both in per capita terms and as a share of GDP. However, the extent of this increase will depend on how successful policies are at containing health care costs. The overarching policy implications from these findings are twofold.

52. First, it is not realistic for countries to freeze health expenditure. *Policymakers will therefore need to plan for at least some increases in health spending over time* – certainly in absolute terms, and most probably also as a share of GDP. The critical point of debate for countries is the extent to which increased spending should be financed from public or private sources. Neither option is straightforward.

53. In terms of public spending, many countries have allowed health to take a larger share of their budgets over time, with health spending now averaging 15% of government spending in OECD countries (OECD, 2017b). In effect, increased health spending in the past has been offset by lower public spending in other areas, such as defence and other public services. Continuing such reallocations to health in the future may be difficult, in the face of competing demands for government resources.

54. Therefore, increases in public spending for health are likely to require higher overall tax rates or increased social contributions. Policymakers need to have an open debate and gauge the willingness of citizens to fund such increases through public means, particularly as some other areas of spending are also likely to grow. For example, public spending on pensions is forecast to increase from 8.9% of GDP in 2013-15 to 9.5% by 2050, mainly due to demographic change (OECD, 2017d).

55. Taxes on tobacco and other sin taxes, for which the public seems to have a high tolerance, could be used more extensively. However, in terms of funds raised these will only have a marginal effect. More broadly, the scope for additional taxation will vary across countries, with some countries already near the upper limit of what is likely to be feasible. Whilst tax-to-GDP ratios in the OECD have been increasing gradually over time on average, ratios for countries with the highest taxation (e.g. France, Denmark) have flat-lined or decreased. Indeed, the tax-to-GDP ratio has never exceeded 49% in any individual OECD country (OECD, 2018).

56. The alternative policy option to increased public spending is to shift some of the spending burden to private finance. This has its own challenges, particularly the risk of worsening inequities. Shifting core services to private financing can lead to gaps in coverage and may not lead to cost-savings. Maintaining universality in terms of population coverage is therefore critical, so that the poor and those with the greatest health care needs are guaranteed access to needed services.

57. Still, there may be scope for more rational decision making on what services are covered by publicly financed schemes, with some non-core services switched to private financing. Positive lists for pharmaceuticals; requirements to prescribe generics; reduced coverage for alternative medicine, glasses and dentistry are examples where some countries have sought to delimit covered services (Paris et al., 2016; OECD, 2017a).

58. The second broad policy implication is that while health spending is likely to increase, *governments can still have a substantive influence on managing the growth in health spending*. Projection results demonstrate the impact that policymakers can have. In

a 'cost pressure' scenario, annual growth in health spending per capita averages 3.1% across the OECD, compared with only 2.2% if countries implement policies that increase productivity and promote healthier lifestyles. In Estonia, Latvia and the Slovak Republic the difference between the "cost pressure" and "full cost control" scenarios is particularly marked, at over 1.3 percentage points.

59. A range of cost containment policies has historically been effective at offsetting, at least to some extent, these upward pressures on health spending. Proven policy examples that can increase productivity include policies on health workforce, pharmaceuticals and new technologies. For example, new laws and regulations that extend the scope of practice for non-physicians can produce cost savings with no adverse effects on quality of care (James et al., 2017b). For pharmaceuticals, price, market entry and prescribing regulations have all helped increase penetration of generics in the market, thereby saving costs (Socha-Dietrich et al., 2017). Health Technology Assessments (HTAs) have the potential to ensure cost-ineffective new technologies are not introduced, and existing cost-ineffective interventions are discontinued (Auraaen et al., 2016). More broadly, stronger price regulation can be effective in reducing health spending (Lorenzoni et al., 2018).

60. There is also considerable scope to better harness technological progress, focusing on those that have the potential to increase productivity. For example, digitalisation can support new delivery methods that save money, notably in the form of telemedicine and robotic tools for some limited procedures; as well as improving the quality and usefulness of health data (OECD, 2017c).

61. Promoting healthier lifestyles requires action both within and beyond the health sector. Curbing the major risk factors of smoking, alcohol consumption and obesity can reduce associated treatment costs. For example, alcohol prevention policies – such as brief GP interventions; taxation; and regulations on opening hours, advertising and drink-driving – have been shown to reduce costs compared to when associated illnesses are treated when they appear (OECD, 2015). Similarly, a range of fiscal, regulatory and communication policies have been cost-effective in reducing rates of smoking, obesity and other major risk factors (see, for example, OECD, 2017c and WHO, 2015 for an in-depth discussion).

5. Conclusions

62. Health spending is set to continue to grow over the medium term for all OECD countries. In the absence of major policy changes, health spending per capita is projected to increase at an average of 2.7% per year across the OECD from 2015-2030, a rate slightly slower than in the past.

63. Health spending is projected to outgrow GDP across a range of scenarios, reaching on average 10.2% of GDP in a 'base' scenario. Spending could reach as much as 10.8% - if cost containment policies are ineffective and rising expectations on health systems are not suitably managed (a 'cost pressure' scenario). With enhanced productivity and effective health promotion policies, health spending growth is expected to be slower, although its share of GDP is still projected to increase to 9.6% by 2030. These figures compare with an 8.8% share of GDP in 2015. Health spending as a share of GDP is projected to increase in every OECD country, with the largest increases expected in the United States mainly due to increases in population and coverage.

64. Income is the main driver of spending growth, accounting for about half of the projected growth in health spending. Demographic effects account for around a quarter of growth. Productivity constraints only account for about one eighth of spending growth in the base scenario, but up to a quarter of spending growth in low productivity scenarios.

65. Public spending on health is projected to grow slightly faster than total health spending, resulting in its share of total health spending rising from 74.2% to 77.4% by 2030. These results are broadly consistent with other studies in terms of the degree of spending growth, although other cross-country projections model public rather than total spending on health.

66. Taken as a whole, these new health spending projections illustrate both the potential and limitations of cost containment policies. Spending is likely to increase in part because citizens want better quality health care, and because technological advancements extend the scope of what health care can achieve. The challenge is how countries can continue to push the boundaries of what health systems can deliver, in a financially sustainable manner, thereby maximising value-for-money.

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Annex A. Technical specification of the projection and regression models

Projection model

67. The projection model used in this analysis follows a component-based approach, which allows projections to be split into sub-categories or components to get more precise estimates of the drivers of expenditure (Lorenzoni et al., 2015). It makes use of age-expenditure curves to model the impact of demographic effects on expenditure, regression methods to estimate the parameters of the model, and scenario analysis to model future developments linked to different types of policy options.

This is a general view of the model:

$$\boldsymbol{Health\ Care\ Expenditure}\ (Total) \xrightarrow[country,time]{} f(Demographics, Income, Wages\ and\ \ Productivity, Technology)$$

$$\boldsymbol{Demographics}\ (Age) \xrightarrow[country,time]{} f(Population\ structure, Death - related\ costs, Dynamic\ equilibrium)$$

$$\boldsymbol{Technology} \xrightarrow[country,time]{} f(Share\ of\ research\ and\ development\ on\ GDP)$$

Where total health expenditure is a function of demographic change, income effects, wages and productivity (Baumol effect), and technological progress. The demographic component is modelled separately from the regression model through the use of age-expenditure curves. Both demographics and technology are used as controls in the regressions, but do not enter the projection model as independent parameters.

68. While previous models focussed on public health expenditure, this model focuses on total current health expenditure, with the aim of disaggregating expenditure into its functions and types of financing at a later stage. The reason behind using total health expenditure as the main output is that most of the studies on the determinants of health expenditure at the macro level use total expenditure as their main term of reference.

69. Therefore, all coefficients and drivers employed in the analysis are benchmarked against the relevant output rather than assuming that coefficients for public expenditure would behave in similar ways. Running regressions on public health expenditure, in fact, shows that coefficients can vary significantly between the two aggregates of expenditure, with income effects being lower, Baumol effect being higher, and demographic variables being much higher and significant compared to regressions on total health expenditure.

Data sources and main model assumptions

70. The first step in the process was to obtain or estimate age-expenditure curves for all OECD countries. Data were obtained for 12 countries (2015) from national sources and the Eurostat HEDIC report (2016), with three countries subsequently dropped due to data issues. The curves were expressed as the ratio of expenditure in a specific age group over

the average spending across all groups. The remaining OECD countries were then modelled by assigning a curve with a similar shape to the observed data, based on the share of long-term care expenditure for each country (OECD Health Statistics, 2018). The final expenditure curves were then obtained by multiplying individual health expenditure in 2015 by the estimated age-expenditure weights.

71. Second, the input parameters for the model were calculated using a set of panel regressions run on historical data (1994-2015) for all OECD countries. The base specification uses demography, GDP, Baumol effect, technology and time factors to estimate health expenditure.

72. The main regressand for the model is total current health expenditure per capita, in real terms and in national currency. A range of other measures of current health expenditure was used in sensitivity analyses (nominal, PPP-adjusted, etc.).

73. For the income effect, series on nominal, real, PPP-adjusted, per capita and total GDP, with 1-year lags, were used. In the base scenario, a country-specific real GDP per capita growth elasticity of 0.74 was used.

74. For the Baumol effect, series on nominal and real wages, total employment and the aforementioned GDP series were used to calculate productivity in the total economy and, subsequently, the Baumol variable (wages growth – productivity growth). In the base scenario, a Baumol effect of 0.265 of country-specific average historic wage growth in real terms was used[7].

75. Demographic and technology effects were used in the regressions as controls, and therefore were not used as direct inputs in projections. Series on share of the elderly, mortality and population by age groups, and share of research and development expenditure in GDP were used as controls in different specifications. Additionally, since all regressions were run with time effects, an average time effect of 0.004 was included for all countries, which varies year by year (based on its standard deviation) to account for its random nature. This coefficient captures cyclical effects and other unexplained systematic increases in expenditure over time. It is derived from the average year intercepts from the preferred regression specification.

76. Finally, health spending was projected using the age-expenditure curves as the baseline. Spending was modelled through the interaction of values predicted from the projections framework with broader demographic and macroeconomic projections available elsewhere. In particular, the demographic component includes population and death projections from the "medium" scenario of the UN World Population Prospect 2017. Income effects were estimated by interacting the regression parameters with GDP growth projections (Guillemette and Turner, 2018); and the Baumol effect was estimated through regression parameters and country-specific observed excess wage growth over productivity growth. The impact of new technologies was embedded in projected values for income, productivity and demographic effects.

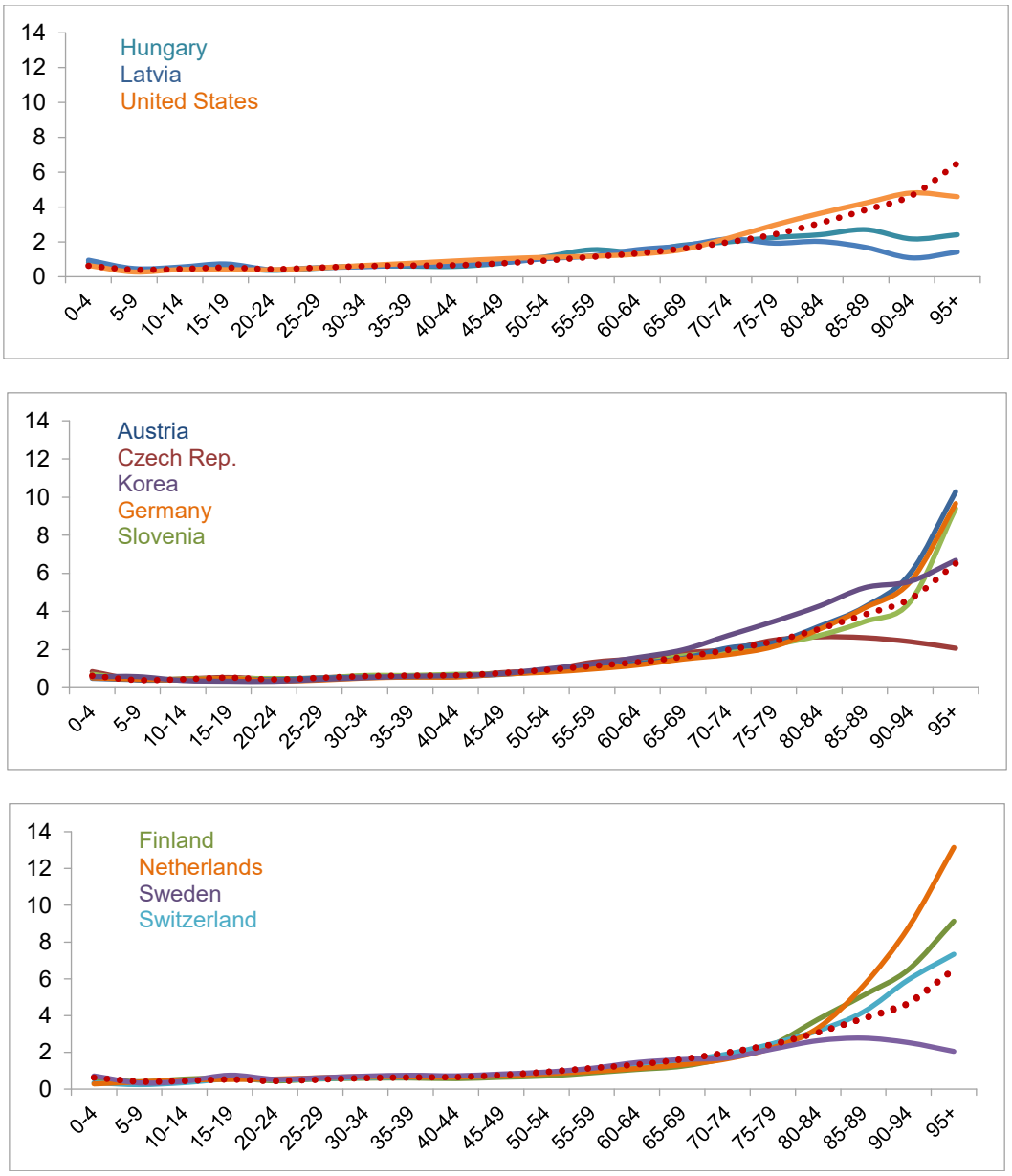
Age-expenditure curves

77. Figure A.1 shows the observed data for 12 countries, from national sources and HEDIC (2016). The curves are expressed as per capita expenditure by age group divided

[7] The average of the Baumol variable for all other countries is used for Colombia, Lithuania and Turkey as time series on wages are not available.

by average per capita expenditure, therefore as a ratio of age-specific expenditure compared to average expenditure in a country.

Figure A.1. Age-expenditure curves, all countries with available data



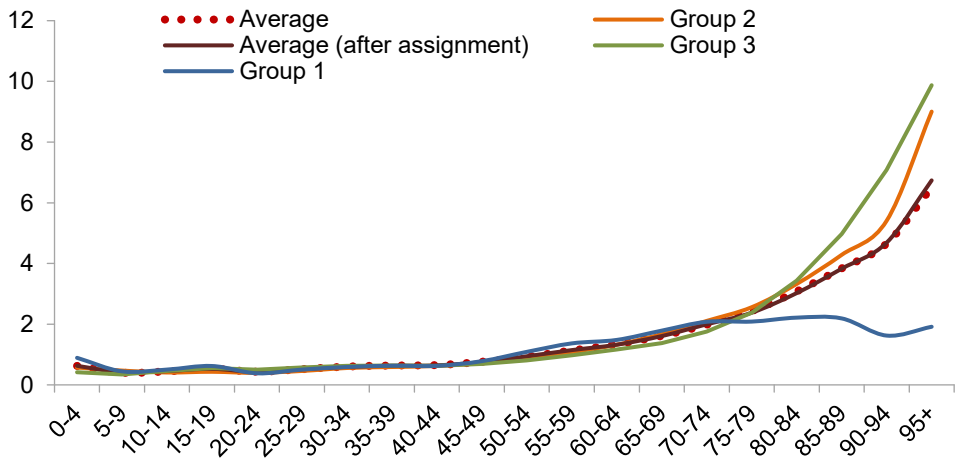
78. The age-expenditure curves for all countries with data are split into three groups based on each country long-term care expenditure as a share of GDP. Normally, age-specific spending compared to average per capita spending goes up with age. The extent of this increase is less marked in countries with very low LTC expenditure (Hungary and Latvia, notably).

79. Three countries - the United States, the Czech Republic and Sweden - were then excluded from the analysis because of the shape of their curves for older age groups. Age-expenditure curves are expected to spike upwards towards the latest stages of life, because

expenditure for people who are closer to death (or in need of nursing care) are exponentially higher than expenditures for all other age groups. Therefore, a curve spiking downwards towards the latest age groups provides an indication that the spending figures used to construct the age-expenditure weights were excluding important expenditure categories, and therefore may be biased for the purpose of this projection work.

80. Figure A.2 shows the averages for the three groups: Hungary and Latvia (group 1); Austria, Germany, Slovenia and Korea (group 2); Finland, Netherlands and Switzerland (group 3). The three group curves were then used as the baseline to assign a distribution to all the countries with missing data. The distributions for the countries with observed data are correlated most closely with the share of long-term care (LTC) expenditure in that country.

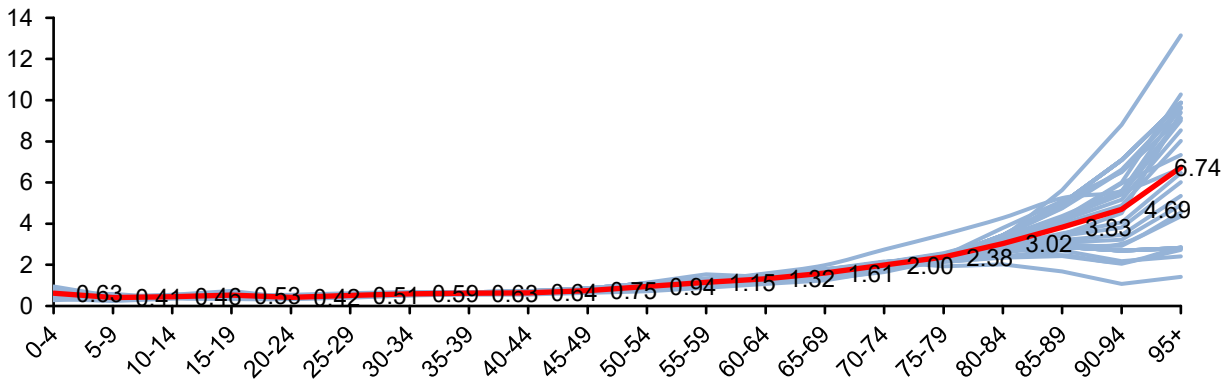
Figure A.2. Comparison of age-expenditure curves, total and by group



81. An index of LTC expenditure was then constructed, assigning the average LTC expenditure to each of the three groups (4.5%, 14.1% and 20.2%, respectively). Curves for all other countries were then estimated based on each country's distance from the LTC expenditure of the nearest group. This essentially weights the nearest group's curve and assigns one with the same shape, but different level compared to the group average. For countries where the LTC expenditure was within that of two groups, an average of the two groups (weighted by the standardised distance from each of the groups) was used.

82. Figure A.3 shows the overall distribution of per capita spending for all countries. Of note that the average distribution for all countries corresponds to the average before indexing and weighting (as can be seen from Figure A.2).

Figure A.3. Per capita expenditure by age group for all countries



83. The above spending curves were then used to estimate the expenditure by age group for all countries. Data from the OECD Health Database for total real health expenditure in 2015 (our baseline year) and UN data for the population by age group were used to derive the age-group specific expenditure. The relationship between these variables is expressed as:

$$(0) \quad For\ any\ individual\ age\ group: \begin{cases} W = \frac{x_{pc}}{\bar{X}} \\ S = \frac{x}{X} \\ S = \frac{W * \frac{X}{P}}{\frac{x}{P}} \end{cases}$$

where W is the weight of expenditure per capita in a specific age group over the average expenditure across age groups; and S is the share of expenditure in a specific age group over the total expenditure, which is derived using the estimated weights, and given numbers for total health expenditure and total population in each country. By converting the weights into shares of expenditure, total health expenditure was distributed to age groups based on its age-specific share of share of the total.

Regression specification

84. The econometric specification of the model follows the mathematical notation of most macro-level studies to harmonise with the largest portion of the literature at the heart of the model. The first difference of the natural log of all the variables (instantaneous growth rate form) is used to avoid the issue of unit roots of level 1 and co-integration (see Box A.1 below on the issue of stationarity of a panel). The general equation can be written as follows:

$$\Delta \ln HCE_{c,t,f} = \alpha + \beta_1 \Delta \ln Demo_{c,t} + \left[\beta_2 \Delta \ln GDP_{c,t} + \beta_3 \left(\Delta \ln W_{c,t} - \Delta \ln Y_{c,t}\right)\right] * \delta_1 Income_{c,t} + \beta_4 \Delta \ln Tech_{c,t} + \eta_c + \tau_t + \varepsilon_{c,t} \qquad (1)$$

85. The dependent variable HCE is health care expenditure in country c for year t and function f (total or public); Demo refers to a proxy for demographic control that takes the

form of the share of the elderly (% of population over 65 years); on β_2 GDP per capita elasticity is measured; on β_3 the Baumol coefficient is estimated, measured as excess real wage growth W over real productivity growth Y in the total economy — both GDP and the Baumol variable can be interacted with a country income group dummy on δ_1 (not included in our baseline regressions); on β_4, the technological progress component is estimated, by using the country research and development spending as a share of GDP as a proxy; lastly, η_c and τ_t are country and time fixed effects, depending on the estimation methods (OLS, fixed and random effects).

86. The Hausman test almost always favours random effect specifications. The use of lags on GDP (one and three years) and R&D expenditure as a share of GDP (one, three and five years) was tested, and coefficients were found to be consistent across regressions, with higher significance on GDP lag of one year (consistent with our projections, where GDP for year t-1 affects health expenditure in the following year) and technology lags of three years. Table A.1 and A.2 below show regression results for a selected set of different specifications, with and without lags, and with and without controls for the share of the elderly. Those regressions use the preferred measure of health expenditure for total and public and GDP, namely per capita real expenditure in national currency units. Regressions in bold show outputs that were used as estimates for the base scenario.

87. Regressions were also run on several other measures of health expenditure, such as nominal health expenditure, PPP-adjusted health expenditure, and health expenditure without LTC expenditure (to check for significant differences in coefficients for the Baumol variable and ageing). According adjustments were made for the GDP and Baumol series to harmonise the data. Outputs from all regressions were used to construct the plausibility range for our parameters.

88. Importantly, the sensitivity of the Baumol variable was tested using different series, such as USD-converted rates and the use of excess wages growth in nominal terms over productivity growth in real terms (Hartwig, 2008, 2011; Colombier, 2017; Bates and Santerre, 2013). It has to be noted that across OECD countries the differential of real wages and real productivity is close to zero on average, with several countries showing slightly negative values across the panel (mostly due to the first decade of the sample). This means that we are unable to use the series on Baumol to project this variable, since we cannot reasonably expect this differential to be positive.

89. It is therefore important to distinguish between the proxy used in regression analysis to capture the presence and magnitude of the Baumol effect – that is excess wage growth in real terms over productivity growth in real terms in the total economy - and the variable subsequently used in the projection model – that is country-specific average growth of wages in real terms in the total economy.

90. In his projections for Switzerland, Colombier (2017) uses a coefficient of 0.4 and 0.6 applied to wage growth in real terms. Our model uses the same series used in regression analysis for estimating the Baumol coefficient (Table A.1 and Table A.2, column (4)). Thus, the coefficient of the Baumol variable shows that a one percentage point increase in the excess wage growth in real terms in the total economy is translated into a 0.265% increase in health spending due to excess health inflation ("real price increases" in Baumol terminology (Baumol 2012, page 6)).

Box A.1. Stationarity

Stationarity of a panel is defined as the property of time series data of having mean or variance that do not change when shifted in time. Several co-integration studies in the late 1990s have found first and sometimes second level unit roots in many countries that are commonly analysed in the literature — unit roots different from zero cause violation of stationarity that must be corrected (some macroeconomic variables are found to have stochastic trends). The use of differencing and logarithmic transformation can help mitigate the non-stationarity of the panels, and these techniques are now common practice in most recent macro studies. (Dreger & Reimers, 2005; Hansen & King, 1996; Herwartz & Theilen, 2003)

Table A.1. Regression results for total health expenditure

	(1)	(2)	(3)	**(4)**	(5)
	FE	FE	RE	**RE**	RE
	No controls	Controls	No controls	**Controls**	No lags
L1.Income	0.581***	0.581***	0.733***	**0.73*** **	
	(0.0763)	(0.0764)	(0.0696)	**(0.0694)**	
Income					0.813***
					(0.0698)
Baumol	0.308***	0.309***	0.264***	**0.265*** **	0.418***
	(0.0589)	(0.059)	(0.0579)	**(0.0577)**	(0.06)
L3.Tech	-0.0334	-0.0342	-0.0108	**-0.0121**	
	(0.0247)	(0.0247)	(0.0235)	**(0.0235)**	
Technology					0.0044
					(0.0226)
Ageing		0.0234		**0.238***	0.094
		(0.172)		**(0.139)**	(0.126)
Constant	0.0228*	0.0226*	0.0161*	**0.0141*** **	0.0122
	(0.0078)	(0.0081)	(0.00783)	**(0.0079)**	(0.0079)
N	513	513	513	**510**	579
Overall R^2	0.299	0.3	0.308	**0.312**	0.323

Note: FE, fixed effects; RE, random effects.
Note: * denotes significance at the .1 level, ** at the .05 level, *** at the .01 level.

Table A.2. Regression results for public health expenditure

	(1)	(2)	(3)	**(4)**	(5)
	FE	FE	RE	**RE**	RE
	No controls	Controls	No controls	**Controls**	No lags
L1.Income	0.717***	0.719***	0.792***	**0.787*** **	
	(0.0908)	(0.0908)	(0.0817)	**(0.0813)**	
Income					0.864***
					(0.0850)
Baumol	0.359***	0.36***	0.307***	**0.309*** **	0.501***
	(0.0701)	(0.0701)	(0.0679)	**(0.0676)**	(0.0717)
L3.Tech	-0.0101	-0.0094	0.0023	**0.0275**	
	(0.0294)	(0.0294)	(0.0276)	**(0.0279)**	
Tech					-0.00391
					(0.0271)
Ageing		0.24		**0.408** **	0.257*
		(0.204)		**(0.162)**	(0.1506)
Constant	0.0086	0.0063	0.00372	**0.00014**	0.0064
	(0.00939)	(0.0095)	(0.00919)	**(0.00925)**	(0.0097)
N	513	513	513	**510**	578
Overall R^2	0.285	0.293	0.288	**0.297**	0.296

Note: FE, fixed effects; RE, random effects.
Note: * denotes significance at the .1 level, ** at the .05 level, *** at the .01 level.

Derivation of Baumol cost disease variable

91. Baumol's model of unbalanced growth can be expressed mathematically as:

$$(2) \quad Y^{NP}(t) = aL^{NP}(t)$$

$$(3) \quad Y^{P}(t) = bL^{P}(t)e^{rt}$$

$$(4) \quad W(t) = W_0(e^{rt})$$

Where only one type of input, labour L, generates output in both the non-progressive (Y^{NP}) and progressive (Y^{P}) sectors. Baumol assumes that, while the non-progressive sector in equation (2) stagnates, with output proportional to the amount of labour introduced, the progressive sector in (3) has output rising at a constant growth of r over time. Baumol further assumes that wages in the two sectors are equal at each point in time, and that they rise over time with productivity improvements in the progressive sector, as per (4). It follows, therefore:

$$(5) \quad C^{NP}(t) = \frac{W_0(e^{rt})}{a}$$

$$(6) \quad C^{P}(t) = \frac{W_0(e^{rt})}{be^{rt}} = \frac{W_0}{b}$$

92. Equation (5) implies that unit costs rise continually over time in the non-progressive sector, depending on productivity improvements in the progressive one, while costs in (6) remain constant over time. This hypothesis can be tested by examining whether unit cost changes in the stagnant sector are directly proportional to the excess of wage rate growth less labour productivity growth in the overall economy, as in:

$$(7) \quad \Delta \log(C^{NP}) = \lambda[\Delta \log(W) - \Delta \log(Y)]$$

93. The expression in brackets is the empirical formulation of the Baumol variable, with W representing overall wages and Y representing output per worker (productivity in the general economy). A positive coefficient for λ provides support for Baumol's cost disease, with $\lambda = 1$ representing a full effect that shows a direct proportional relationship between general productivity in the economy and wages in the non-progressive sectors of the economy (in our case, health).[8]

[8] Derivation taken from Bates and Santerre (2013) and Hartwig (2008, 2011).

Constructing the model

94. The following table details a legend for the construction of the projection model:

Table A.3. Model legend

Data variables	Notations	Parameters	Functions
i = income per capita	*pc* = per capita	μ = death-related costs + dynamic equilibrium	ϕ = actual population
x = total *individual* health expenditure	*g* = age group	ϵ = income elasticity	α = income effect
y = total *collective* health expenditure	*t* = year	η = Baumol coefficient	β = Baumol effect
p = total population		θ = time coefficient	γ = time effect
π = absolute number of deaths *w* = nominal wages *P* = real productivity			

95. Health spending is projected for each country, year and age group. Health spending is initially split into individual (X) and collective (Y) expenditure.

The income effect is calculated by multiplying the income elasticity by the projected GDP growth:

$$\alpha = x_{\{(t-1,pc,g)\}} * \left(\left(\frac{\{i_{\{(t)\}} - i_{\{(t-1)\}}\}}{\{i_{\{(t-1)\}}\}} \right) * \epsilon \right)$$

The Baumol effect is calculated by multiplying the Baumol coefficient by the average annual wage growth:

$$\beta = x_{\{(t-1,pc,g)\}} * (\eta * (\Delta w_t))$$

To calculate the death-related cost effect, the survivors for the base year (t–1) for each age group are calculated by subtracting the absolute number of deaths from the total population:

$$\phi_{\{(t-1),g\}} = \rho_{\{(t-1),g\}} - \pi_{\{(t-1),g\}}$$

The death-related cost effect is calculated by multiplying the given expenditure for each age group by the population weighted by the share of survivors in that year:

$$\mu = x_{\{(t-1),pc,g\}} * \frac{\{\phi_{\{(t-1),g\}}\}}{\{\phi_{\{(t-1),g\}} + (\pi_{\{(t-1),g\}} * \tau)\}}$$

The time effect is a fixed parameter, multiplied for each year and age group by a random weight between 0.5 and 1.5:

$$\gamma = x_{\{(t-1,pc,g)\}} * (\theta * [0.5 - 1.5]_{a.t})$$

The parameter effects are summed to the per capita expenditure:

$$X_{\{(t-1,pc,g)\}} = x_{\{(t-1),pc,g\}} + \alpha + \beta + \mu + \gamma$$

The projections for individual health expenditure is obtained by multiplying the per capita expenditure by the new population in each age group for the following year:

$$X_{\{(t),g\}} = x_{\{(t-1),pc,g\}} * \phi_{t,g}$$

The expenditure is then summed over all age groups to obtain the total individual health expenditure for year *t*:

$$\sum_{\{g=1\}}^{n} X_{\{(t),g\}}$$

The collective health expenditure is allowed to grow with respect to all parameters, except for population changes and death-related costs:

$$Y_{\{(t-1),pc\}} = Y_{\{(t-1),pc\}} + \alpha + \beta + \gamma$$

The projections for collective health expenditure is obtained by multiplying the per capita expenditure by the new population for the following year:

$$Y_t = Y_{\{(t-1),pc\}} * \phi_t$$

The projected collective expenditure is then summed to the projected individual expenditure to obtain the projected total health expenditure in year t:

$$HCE = \sum X_{\{(t)\}} + Y_t$$

96. The total expenditure resulting from the above calculations is then used as the baseline for the following year, iteratively for all years of the projections. The share of individual and collective health expenditure across years is kept constant, and projections are not modelled based on alternative demographic scenarios (except for variations of the share of non-survivors through changes in death-related costs and life expectancy gains).

Data sources, limitations and further work

Table A.4 below lists the sources for all of the data used in our projections.

Table A.4. Data sources

Data	Source	Comments
Health expenditure data	OECD Health Database (2018)	Expenditure, financing shares, etc.
Population	OECD Health Database (2017)	Historical series
Population and mortality projections	UN World Population Prospect (2017)	Data from 2015 onwards
Age-expenditure curves	National sources, HEDIC (2017)	Data for 12 countries
GDP	OECD (2018); Guillemette and Turner (2018)	Historical and projected
Wages	OECD Health Database (2018)	
Productivity	OECD (2018)	
R & D share	OECD (2017)	
Share of the elderly	OECD Health Database (2017)	
Life expectancy	UN World Population Prospect (2017)	

97. Data availability is limited by the need to maximise the comparability of results across countries. One of the main limitations of our projections is the lack of observed data for the age-expenditure curves for a significant portion of our sample of countries. Obtaining a precise breakdown for the missing countries, instead of using estimated data, would result in more statistically robust predictions. Similarly, some of the historical data used for the regressions might be inherently plagued by breaks, missing observations and measurement errors that could bias our estimations. This is particularly the case for our proxy of technology, and to a lesser degree our Baumol variable.

98. Future iterations of the model can improve the estimation in two ways: first, by estimating cluster-specific (or possibly country-specific) coefficients for income elasticity. Studies have found that elasticity is closely related to a country's income (Dieleman et al., 2016), with the bell-shaped hypothesis finding moderate support (whereas middle-income countries have higher elasticity than low or high income – this pattern carries over when studying only a sample of high income countries, finding that the ones in the second tertile of income generally have higher elasticities). Second, the model would benefit from actual projections of wage growth so that the Baumol coefficient is allowed to change over time rather than being a fixed growth based on historical data. Similar projections on the individual and collective shares of expenditure would also positively refine the model.

99. The model is built in a way that allows for different model specifications according – as an example - to the function of care (e.g. pharmaceutical, long-term care). Future work may also explore the possibility of embedding estimates of changes in the prevalence of diseases over time as determinants of health spending trends.

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