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Health expenditure and health outcomes:

The importance of discussing associations

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Abstract

Introduction: This study aims to contribute to a better understanding of the links between health outcomes and health expenditure, using data from OECD countries from 2002 to 2017.

Data and methods: This is a longitudinal panel data study. Responses included the all-cause deaths, years of life lost, preventable and treatable mortality. Explanatory variables included total and public health expenditure per capita. Covariates accounted the share of elderly, of unemployment, and of adults smoking daily, along with GDP per capita. Univariate descriptive and bivariate statistics were presented, along with multivariate analysis using generalized mixed linear models, with gamma distribution, logarithmic link function.

Results: There is an absence of association between total spending and health outcomes after controlling for all covariates including GDP, showing that spending is not related to outcomes. Significant though positive relationships were found only between spending from public sources and years of life lost and preventable mortality, after controlling for all covariates including the effect of wealth.

Discussion: Several reasons may account for the lack of association between health expenditure and health outcomes, along with the positive links between public expenditure and outcomes, namely the period under analysis, the role of other health determinants excluded from the study, factors not covered by expenditure but reflected upon outcomes (like traffic accidents and underdiagnosed conditions), and further elements that affect expenditure without a sizable effect on results (like technological progress, and expectations). In the case of public spending, allocation of funds across functions of care, along with a focus on interventions for those in lower socio-economic position could also be relevant.

Conclusion: Caution should be taken when judging the association of health expenditure, total or from public sources, and outcomes in OECD countries, as additional factors should be measured and further researched.

Key words: Health expenditure, public health expenditure, GDP, all-cause mortality, years of life lost, preventable mortality, treatable mortality

Resumo

Introdução: Este estudo pretende contribuir para a maior compreensão das relações entre resultados de saúde e despesa com saúde, usando dados dos países membros da OCDE, entre 2002 e 2017.

Dados e métodos: Neste estudo longitudinal, as variáveis dependentes incluem o número de mortes, os anos de vida potencialmente perdidos, mortalidade evitável e mortalidade tratável. As variáveis explicativas de interesse incluem a despesa com saúde, total e de fontes públicas, *per capita*. As demais variáveis independentes compreendem a taxa de pessoas com mais de 65 anos de idade, de desemprego e de adultos que fumam diariamente, além do PIB *per capita*. Análises descritivas univariada e bivariada são apresentadas, junto com uma análise multivariada realizada com modelos lineares generalizados mistos, de distribuição Gamma e função de ligação logarítmica.

Resultados: Observa-se a ausência de associação entre despesa total com saúde e resultados de saúde, depois de consideradas todas as demais variáveis independentes incluindo o PIB, evidenciando que a despesa total não se relaciona com os resultados. Associações significativas e, contudo, positivas foram encontradas entre despesa pública e anos de vida potencialmente perdidos e mortalidade evitável, uma vez consideradas também todas as demais variáveis independentes incluindo a riqueza.

Discussão: Várias razões podem justificar os resultados da análise, nomeadamente, o período em análise, o papel de outros determinantes excluídos do estudo, fatores não cobertos pela despesa mas refletidos nos resultados (como acidentes de viação e doenças sub-diagnosticadas) e, em sentido oposto, elementos que, afetando a despesa, não exercem influência relevante nos resultados (como o progresso tecnológico e as expectativas dos indivíduos). No caso da despesa pública, a alocação de fundos às funções do cuidado e o enfâse em intervenções para pessoas em pior situação socioeconómica podem também ser razões significativas.

Conclusão: Avaliações sobre a associação entre despesa, total ou pública, e resultados de saúde, em países da OCDE, devem ser realizadas com cautela, pois fatores adicionais devem ser considerados e investigados.

Key words: Despesa com saúde, despesa pública com saúde, PIB, mortalidade, anos de vida potencialmente perdidos, mortalidade evitável, mortalidade tratável

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1. Introduction

Relevance of the topic

Whether investing in health care is truly worthwhile and actually linked to intended health results, or if we have come to a point in which expenditure has no further effect on outcomes is a recurrent dilemma, even more so considering the sheer value involved.

On one hand, there is the common understanding that health is a fundamental right of every human being without distinction of race, religion, political belief, economic or social condition, crucial for peace. Basic to happiness, harmonious relations and security is the principle that “health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (1). While a “critically significant constituent of human capabilities which we have reason to value” (2), better health for all “is right and just” (3). A pillar of societal progress that goes far beyond the realm of economics, health should be a priority by nature, a central piece on poverty decline, and a strategic investment aimed at increasing income (4–6). Tackling health-related challenges is a complex endeavour because health is influenced, directly and indirectly, by a great number of factors around which, today, there is an extensive body of knowledge covering their nature, their evolution, the links determinants establish among themselves and how they affect health and life itself (7,8).

On the other hand, policy and decision makers, as well as families and individuals, have to manage resources and choose, among conflicting needs and demands, which portion of their budgets should be dedicated to health or invested in other domains. Health expenditure is generally understood as the final consumption, both individual and collective, of all health goods and services provided (9). To make good on commitments to Health, a large portion of wealth in OECD countries is currently dedicated to such goods and services. According to OECD’s *Health at a Glance* from 2019 (10), in 2018, countries spent on average 8.8% of their GDP on health, and nearly 4000 US dollars per person at purchasing power parity. Since 2012, spending returned to positive annual growths of 2.3% on average until 2018, outpacing GDP, and in 2017, governments dedicated 15% of their budgets to health, while 74% of spending was financed through schemes enforced by law. In contemporary literature, the link between spending and outcomes has been controversial, with some researchers pointing to a missing association, while others observe an opposite reality.

Understanding whether or how strongly health expenditure relates to better health or if it translates into unnecessary care is, therefore, crucial. And it is so not just for the sake of optimizing resource allocation by governments or families, making the most and best out of our personal and collective contributions, but also for a deeper and common awareness of facts by stakeholders, from direct decision makers to providers, media, communities, insurance, industry, and researchers. As this dissertation is being written, there seems to be little doubt on the importance of health, and the value of human life. Public treasury is being consensually requested to ensure our basic right to health, while sustaining care in a time of severe economic frailty. Yet, times will evolve. The question around the worthiness of spending is bound to return to public debate, especially now that political agendas are changing across Europe and absorbing expectations of a new economic and social crisis. The link between spending and health outcomes should be further explored in the absence of global emergencies, when claims are less obvious.

This dissertation

In order to address previous concerns and contribute to a better understanding of the relation between health outcomes and health spending, using data from OECD countries from 2002 to 2017, this study will try to answer the following questions:

- What is the link between health outcomes and health spending?
- Is a similar link observable between health outcomes and health spending from public sources?

The following chapter will review literature around health determinants, outcomes and expenditure, also examining previous works on the association of outcomes and spending to provide guidance on the construction and interpretation of findings (chapter 2). In chapter 3, data, variables and methodology will be laid out, with outcomes including the number of all-cause deaths, years of life lost, preventable and treatable mortality, with predictors accounting for health expenditure, both total and from public sources, and also incorporating selected covariates. Chapter 4 will present the results of descriptive statistics, along with bivariate and multivariate analysis of relationships, and chapter 5 will discuss them. Finally, chapter 6 will take note limitations of the study, chapter 7 will contain concluding remarks.

2. Research determinants, outcomes and the association of determinants and expenditure

To proceed with the purpose of this dissertation, research of previous scientific work will explore four topics. First, it will overall frame and address factors that contribute to health, including but also going beyond expenditure, through the influential model set by Dahlgren and Whitehead (8) three decades ago. In order to illustrate the complexity of these contributions, some of these pieces of the puzzle that constitutes health will be briefly explored, allowing conclusions on which independent covariates, other than expenditure, to cover in the analysis, and also, as importantly, on which factors will remain excluded. Second, because there are several different indicators used to measure the health of individuals, this section will also describe their most salient features and disadvantages in order to support the selection of dependent variables made in the following section. Third, in order to guide the selection and construction of independent variables of interest, the study will briefly explore the nature of health expenditure and its financing schemes. Fourth and finally, this chapter will cover a revision of previous literature about the association between health outcomes and health expenditure, a piece that will guide the design, the comparison and the interpretation of results later on this work.

2.1 Health determinants

Genetics, the income we have available, where we live or work, ties we establish, our nutritional and exercise behaviours, the educational level our parents attained, the pollution we are exposed to, are just some of the factors that intersect each other in complex ways, affecting health across life. Dahlgren and Whitehead (1991) systematized determinants of health in five levels of influence (Figure 1) (8):

- The structural environment, including the general socio-economic, cultural and environmental conditions in which a person lives;
- Material and social conditions in which people live and work, like housing, education, health care, housing, work environment, unemployment, access to basic services like water and sanitation, and other factors that affect daily living;
- Social and community networks, with the links established between individuals and their peers, including family, friends or neighbours, and their local communities;

- Individual lifestyles, including actions undertaken by the individual regarding food, smoking, drinking, and physical activity;
- Constitutional factors, like age, sex, genetic make-up.

While constitutional factors also play a part in determining health but are rather constant and little prone to change by health policy, all other levels of determinants influence each other and can be vertically and synergistically integrated, across global challenges, sectors, locations, groups of individuals, and individuals themselves.

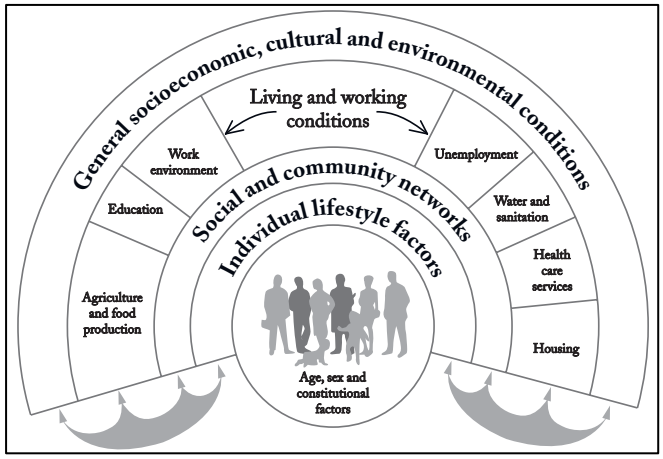


Figure 2: The Main Determinants of Health

Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health: Background document to WHO – Strategy paper for Europe [Internet]. Stockholm: Institute for Future Studies; 1991; p. 11

As Dahlgren and Whitehead (2006) later explained, the model also accounts for successive interactions among levels of influence, by which, for instance, individual lifestyles are shaped by communities, and material and social conditions, or conditions in which people live and work are defined by the wider structural environment, evidencing the downstream or upstream links among determinants. Although differences are not always clear, a holistic approach to determinants needs to consider whether they constitute positive, protective or risk factors. Positive factors contribute to the conservation of health, like economic security and social relationships; protective factors eliminate the risk of disease or enable resistance, like immunization, social support or a healthy diet, and risk factors cause health problems that could potentially be avoided, such as pollution and smoking (11).

Research on determinants in each level of influence

Throughout the last decades, research has shown the importance of specific factors in determining the health of individuals. Although their effect is seldom isolated, the most relevant determinants, as set out by Dahlgren and Whitehead (1991) (8), amenable to policy interventions are briefly explored below.

Structural environment in which individuals live are known to greatly affect health through different pathways, sometimes evolving in different directions. From a socio-economic standpoint, economic growth and income are a first example. Focusing in the US, Lochner et al (2001) (12) and Duncan et al (2002) (13) found an inverse relation

between income and mortality, while the link was in the opposite direction for Granados (2005) (14), that analysed the effect of recessions in health. For New Zealand, Blakely, Atkinson and O'Dea (2003) (15) found, however, no association between regional income inequality and all-cause mortality. From a cultural perspective, institutional and political settings also contribute to health. Overall, Navarro and colleagues (2006) (16) plus Lundberg et al (2008) (17), for OECD countries, along with Lynch and colleagues (2001) (18), for 22 countries in the Luxembourg Income Study at the time, found that redistributive welfare and labour market policies, trade union membership, political representation by women, social security pensions for dual earner families, and basic social security pensions were linked to better health outcomes, from infant, child and old-age mortality to life expectancy. However, Mackenbach (2012) suggested that health inequalities persisted or widened despite the development of welfare states in Western Europe (19). Commercial activity also has a role in how health of individuals unfolds. As per Kickbusch, Allen and Franz (2016), marketing, lobbying, corporate social responsibility, large supply chains, and global trade and investment could be seen as magnifying the impact of commercial activity and reinforce the growth non-communicable diseases (20). Environmental conditions are a major factor determining for health, especially nowadays. In 2003, Finkelstein and colleagues observed that mean air pollutant level was higher in lower income neighbourhoods with a higher risk of death from non-accidental causes (21), while Woodward et al (2014) posited that climate change is expected increase disease from intense and extreme weather conditions, reducing food production, capacity to work and productivity, changing in patterns of communicable diseases, and thus intensifying current health problems (22).

Material and social conditions are themselves shaped by the structural environment, while a reflection of a diverse spectrum of factors, from which education, occupational class, unemployment and the health care system stand out. When it comes to education, Lleras-Muney (2005) (23) in the US, von dem Knesebeck, Verde Dragano (2006) (24) and Cutler, Huang and Lleras-Muney (2015) (25) in Europe, and finally Gakidou and colleagues (2010) globally, (26) showed that the higher the level of education the better health outcomes are, from child and adult mortality, to morbidity level, and life satisfaction. Work environment is another factor that helps explain how health of individuals develops. In 1978, Marmot and colleagues (27), in their longitudinal Whitehall Study conducted in the UK (27), Smith, Bartley and Blane in 1990 (28), Lahelma and colleagues in 2005 (29), for Finland, proved the existence of health inequalities based on occupational class, consistently finding that the lower the occupational or social class the worse the health status of individuals, with Lahelma, Laaksonen, Aittomäki (2009)

(30) additionally demonstrating the mechanism applied to different sectors of activity. Relating to how unemployment affects health, Gerdtham and Ruhm (2006) (31) for the OECD region, Granados and Ionides (2017) (32) for European countries, Schaller and Stevens (2015) (33) and Strumpf and colleagues (2017) (34), both for the US, found an inverse association between unemployment and several measures of mortality, either all-cause and cause-specific, while Stuckler and colleagues (2009) (35) for the European Union, Gili and colleagues for Spain (2012) (36), and Chang and colleagues (2013) (37) for selected American and European countries came to the opposite conclusion with regards to mental health disorders, alcohol use, suicide and homicide, supported by a review of the effects of long-term unemployment by Herbig, Dragano and Angerer (2013) (38), with both streams stressing the role of social protection in mitigation such effects, and Brand (2015) (39) adding that settings of extensive unemployment seemed to reduce the social and psychological impact of unemployment in the US.

Health care systems also affect the conditions in which people live. As Marmot (2007) suggested, national health systems are central to address health inequalities, well-being, protection against vulnerability, and social cohesion and security (3). Back in 1986, Poikolainen and Eskola showed that health services were estimated to account for a 50% decline in mortality from amenable causes from 1969 to 1981, in Finland (40). Muldoon et al (2011) revealed that factors like higher physician availability were significantly associated with reduction of infant and child mortality rates, while out-of-pocket spending was a risk factor for both measures (41). For Arah and colleagues (2005), factors amenable to public health, like immunization or health care coverage, were found to lead to lower all-cause mortality and premature death. In the US, Brown (2014) reinforced the relation showing that expenditure in public health reduced all-cause mortality (42). Recently, Case and Deaton (2020) have incisively suggested that, in the US, the design and development of its particular health care system is a corner stone for a unique increase in mortality rates for white non-Hispanic and less educated adults, identified after the turn of the 21st century, not only for the shear direct cost of care and insurance, but also for the pervasive impact of “extraordinary and extraordinarily inappropriate” (38, p.191) health costs in the wider economy, by promoting a stagnation of salaries, a change in the nature of employment to more precarious and less dignifying jobs, and an upward redistribution of income, within a sector that account for nearly a fifth of the wealth generated in the country, affecting family and social bonds, generating social pain and suffering, and thus what the authors call deaths of despair (43).

Social and community networks are a third group of determinants, closely affected by material and social conditions. The concept of social capital is a central piece of this

matter, one that has been deeply explored over the last decades as a determinant of health or a mediator of other determinants. According to Pierre Bourdieu, in 1986, social capital involves potential resources linked to a network of relationships that provide its members with a collectively owned capital. Such network is the product of specific investment of sociability, time, energy, and economic capital (44). Coleman (1988) suggested that social capital is a particular kind of resource generated within the structure of relations among individuals that facilitates action, being productive as it allows the attainment of specific goals, otherwise impossible (45). Social capital was explored as mediating the relationship between income inequality and mortality, showing to be positively associated with good outcomes, according to Kawachi and Kennedy (46), Kawachi and associates (47), both in 1997, and Kawachi and Kennedy, in 1999 (48). It was also addressed by Mitchell and LaGory (2002) as mediating economic and environmental sources of stress, and mental health with opposite results (49). The direct effect of social capital on several health outcomes, like self-rate health, mental health, and mortality, has also been addressed in the works of Kawachi, Kennedy and Glass (1999) (50), Caughy and colleagues (2003) (51), Blakely and colleagues (2006) (52), Ziersch and Baum (2004), (53) Kouvonen et al (2008) (54), Oksanen and colleagues (2010) (55), and Flores et al (2014) (56). Local experiments have been carried out to assess the potential for intentionally developing social capital with benefits on health, with positive results according to Pronyk and colleagues (2008) (57), and Ichida and colleagues (2013) (58).

Individual lifestyles and behaviours are closely linked to the conditions in which people live and work, and the social links they established with peers and the community, comprising the last set of determinants amenable to health intervention, according to Dahlgren and Whitehead's work, from 1991 (8). Research in the impact of such behaviours in health has been extensive. As per Lim and colleagues (2017) (59), Gakidou and colleagues (2017) (60), and Stanaway and colleagues (2018) (61), physical inactivity, diet, tobacco, alcohol and drug use, child nutrition and breastfeeding, violence towards partners or children and unsafe sex were some of the most prominent causes of the burden of disease worldwide, with prevalence varying according the level of development of each region, and exposure to such risks accounting for an estimated 23.8 million deaths in 2017, according to the last. Wijndaele et al (2011) (62) and Sanders and colleagues (2019) (63) added that total screen time in general and television time in particular, were linked to worse health outcomes, including all-cause mortality, mortality from cardiovascular disease, body mass index, and perceived health status. McKnight and colleagues (2011) (64) also found that insufficient sleep in the case

of adolescent students from the US was associated with the use of cigarettes and marijuana, alcohol and sugar consumption, sexual activity, suicidal ideation, feelings of sadness and hopelessness, fighting and physical inactivity. Moore and colleagues (2016) (65), along with Lee and colleagues (2012) (66), found that physical inactivity contributed to coronary heart disease, type 2 diabetes, and several types of cancer, having caused an estimated 9% of worldwide mortality in 2008, according to the last. With regards to smoking, and although the prevalence of daily consumption in adult population decreased in the last decades while the number of smokers increased due to population growth as observed by Ng and colleagues (2014) (67), according to Lantz et al (2010) (68) and Reitsma and colleagues (2017) (69), it has been associated with mortality, renal failure, intestinal ischemia, hypertensive heart disease, infectious, respiratory diseases, breast and prostate cancers, accounting for around 11.5% of deaths worldwide and for inequalities in mortality among European countries, according to Mackenbach and colleagues (2017) (70).

Socio-economic determinants: extent and implications

Socioeconomic determinants prove that health is also the multidimensional product of complex layers of dynamic, intertwined (and gradient-forming) factors, which have to be understood beyond straight univocal associations with health outcomes. As explored in the last decades (67), they stream from Dahlgren and Whitehead´s (8) concepts of structural environment, and material and social conditions, and result in differentiated impacts on the health of specific groups. They represent the circumstances in which people are born, grow up, live, work and age, which influence a person's opportunity to be healthy, the risk of illness and life expectancy. Because unrelated to biological or other predetermined factors, but instead streaming from social, economic and behavioural factors influenced by policy, an uneven distribution of such determinants across groups in society engenders systematic, unfair and potentially avoidable differences in health (8,71). Correcting such avoidable differences is believed to be an ethical imperative of social justice (72), aimed at development and the attainment of one's full health potential (8,73). Inequalities streaming from socio-economic determinants consistently affect disadvantaged groups, like the poor, ethnic minorities, women and the elderly, leading to worse health or greater risks, and placing them at a further disadvantage (74), with the social gradient of poverty in health as a particular challenge (75). By the end of the century, based on the accumulated associations found, across time and countries, between socioeconomic status and health, Link and Phelan (1995) had already advanced the theory of the Fundamental Causes of Disease, arguing

that the first is a fundamental cause of second. The Commission on the Social Determinats of Health (2008) warned about the social gradient in health, by which the lower the socioeconomic position, the worse the health, with differences caused by an unequal distribution of power, income, goods, and services, along a consequent unfairness in access to health care, education, working conditions, leisure, or housing (76). Marmot and colleagues (2008) added that action across determinants requires addressing the roots of inequality across the life course, particularly the construction of social hierarchy, and the social conditions in which individuals grow, live, work and age, while promoting cohesion through social protection and economic arrangements, and health delivery systems that prioritize health as a human-rights (64). Research on the role of socioeconomic status in health inequalities is extensive, joggling many factors affecting health across societal groups. From Sorlie, Backlund and Keller (1995) (78), Braveman et al (2010) (79), and Case and Deaton (2015) (80), for the US; along with Smith et al (1998) (81) the Acheson Report (1998) (82), for the UK; Denton, Prus, and Walters (2004) (83), for Canada; and Mackenbach (2006) (84) in European countries, many studies have observed the link between groups of factors like education, income, employment status, occupational class, race and ethnicity, social traits (such as marital status, social support, and family setups), or psychosocial factors, with health outcomes and health inequalities. Moreover, in 2011, Mackenbach, Meerding and Kunst showed that socioeconomic inequalities in the European Union, accounted for over 700.000 deaths per year, 33 million prevalent cases of ill-health, and 20% of the total cost of care, eating away around 1.4% of GDP per year (85). Reversed effects of poor health on socioeconomic status have also been addressed. In 1999, Smith (86) observed that reduced working capacity and expanding medical expenses from poor health restricted the household's earned income and savings, Suhrcke and colleagues (2005) (87) pointed that health also affected the participation of household members in the labour market, performance and retirement age. Prior health, even in distant ages, appeared to influence future revenue, via factors like education, absenteeism, productivity, medical costs, income, retirement age, behaviour, along with health shocks, accumulating disadvantages. Cutler, Lleras-Muney and Vogl (2008) explored the gradients formed between socioeconomic status and health, showing that the mechanisms through which determinants operated varied and changed across stages of life, with early years having a crucial role in defining status and health during adulthood, when the association reverses and health affects wealth. Researchers suggested differential patterns of causality, with some socioeconomic factors determining health, some being determined by health, and others mutually formed (88). Causal interdependence is another subject of interest for many authors. In 2004, causal interdependencies between socioeconomic

determinants of health (education, occupational class and household income) were observed by Lahelma and colleagues, with each forming a clear graded relationship with health, mediated or explained by one or both of the remaining factors (89). As per Adler and Stewart (2010) (90) and Braveman, Egerter and Williams (2011) (91), health disparities are multilevel, with interactions being established among factors across life, demanding multidimensional interventions to tackle multiple determinants simultaneously. A life-course approach has been developed by many researches, adding the dimension of time to the study of factors affecting health. In 2001, Case, Lubotsky and Paxson supported the idea of an intergenerational transmission of socioeconomic status, in the US, as childhood health was found positively associated with the family's income, with such link consolidating as children aged and the effect of low income accumulating during life (92). Later Case, Fertig and Paxson (2005) found that, after accounting for parental income, education and social class, children with poor health presented worse educational accomplishment and health status, and lower social rank during adulthood. Conditions during fetal development and childhood proved to have a far-reaching impact on health and socioeconomic status way into adulthood, both directly or mediated by health and economic conditions at early adulthood. Findings reinforced the intergenerational pathway that led those born in poorer families to poorer health during childhood, lower educational attainment, and consequent poorer health and lower income during middle age, placing themselves in the position of perpetuating the phenomenon (93).

2.2 Health outcomes

To assess the impact of determinants on health, the first step is to understand how health should be measured. According to Karanikolos and colleagues (2013), the most common measures of population health may be grouped in three categories: mortality, morbidity and risk factors. Mortality informs a wide range of indicators. Generic indicators summarize total mortality in a specific population and period, with age-standardized death rates and life expectancy as the most frequently used due to availability and reliability of data. The lack of information on cause of death seldom allows reliable judgment on the role of health systems in health. Because neonatal and post-neonatal, different in nature, are often included in infant mortality, assessment of the contribution of care to health is also hard to do. Survival rates are disease-specific indicators, based on the average length of time that individuals survive after diagnosis. Summary measures give rise to health expectancies and health gaps. The first provide an estimate of how much may an individual expect to live free of a specific condition or limitation,

including measures of active life expectancy, disability-adjusted life expectancy, and health-adjusted life expectancy (HALE). The last measure the difference between set norms for the population and the actual condition-specific performance, frequently expressed by years of life lost (YLL). The most well-known indicator addressing the role of the health system in the health of individuals is avoidable mortality. Amenable or treatable mortality is a subset of avoidable mortality that considers only those conditions that could have been directly influenced by appropriate and timely health care, while preventable mortality is the portion of avoidable mortality that could have been avoided by population-based interventions. Morbidity is measured mainly through self-reported or perceived health status, with results not detached from health interventions, but subject to the respondent expectations, not prone to standardization, controversial, and scarcely or irregularly collected (94). Low birth weight also reflects a disease-specific morbidity measure, but is officially reported (95). As deaths rates decline and life expectancy expands, Robine, Romieu and Cambois (1999) also argued in favour of indicators related to health expectancy, namely, disability free and healthy life expectancies, congregating the joint influence of mortality, and morbidity. Such health expectancies combine life expectancy with a specific concept of health in order to estimate the number of years lived in different health status, given disease, impairment, disability, and even perceived health. The authors found that life expectancy was positively associated with disability-free and impairment-free life expectancy, while gender differences existed for life and health expectancies, as well as for morbidity-free life expectancy. Social inequalities became greater with health expectancies, with those poorer and least educated experiencing worse outcomes in disability and impairment-free life expectancy. Overtime, total and severe disability-free life expectancy progressed in the same way, showing that despite living longer, impairment and disability are less acute than in the past (96). As Papanicolas and Smith (2013) pointed measures of population health generally do not account for the contribution of health systems, lack timeliness and precision, while differing national and international standards turn comparisons among countries and time periods inaccurate (97).

Indicators of health status most commonly used by OECD reports are grouped around mortality and morbidity-related measures (98). Mortality indicators (99) are defined as follows:

- Life expectancy: At birth or at different ages, measures the average number of years that an individual at that age is estimated to live, if mortality levels at each stage of life remain constant (100). Life expectancy at birth reached an average of 80.7 years

in 2017, across OECD countries, more than 10 years higher than in 1970, with gains however slowing in recent years (10).

- Mortality and cause-specific mortality: Mortality rates are based on the number of deaths registered in a country in a year divided by its population (10). In order to compare mortality across countries, rates are often age-standardized. Mortality by cause of death is calculated based on the International Classification of Diseases (ICD-10) according to the WHO Mortality Database, accounting for over 20 different causes (101). In 2017, more than 10 million people died in OECD countries. All-cause mortality averaged 801 deaths per 100,000 population (10).
- Infant mortality: Stands for the probability that a child born in a specific year will die before reaching the age of 1. Represents the number of such deaths per 1000 live births (102). Infant mortality averaged 3.5 deaths in 1000 live births, being below 5 in 25 out of 36 OECD countries. More than 60% of deaths during the first year of life occurred before the 28th day, from conditions like congenital anomalies and prematurity (neonatal mortality). Deaths occurring later are due to birth defects, infections, accidents or sudden death syndrome (post-neonatal mortality) (10).
- Maternal mortality: Represents the number of maternal deaths, per 100 000 live births, including ICD-10 codes O00 to O99 (103). Because nowadays maternal mortality entails very low figures in OECD countries, being subjected to large fluctuations, the measure is seldom contemplated in health reports.
- Potential years of life lost: Indicates premature deaths by summing, from deaths believed to be preventable and occurring at younger ages, all the remaining years that should have been lived, up to a chosen limit of 75 years. Generally disease-specific, it is based upon the same causes that measure mortality (104).
- Avoidable mortality: Involves the notions of preventable and treatable deaths. The first is originated by causes of death potentially avoided by public health and primary prevention interventions (i.e., earlier than the inception of disease). Treatable (or amenable), in turn, streams from causes that could be avoided by timely and effective care interventions, including secondary prevention and treatment (i.e. after the beginning of disease) (105). Avoidable mortality grasps the general effectiveness of the system in reducing the number of premature deaths from specific conditions. In 2017, more than 2.9 million deaths could have been avoided in OECD countries. 1.85 million through primary care and public health, and over 1,05 million by treatment (10).

Measures of morbidity used by OECD (106) are formulated as set below:

- Perceived (or self-rated) health status: Stands for the proportion of population aged 15 years and older who reports a specific level of health, generally from good and very good to bad and very bad, and may be disaggregated by age, gender, and socio-economic status or disease. Reflects a person's perception, and is usually self-measured by surveys (107). Cross-country appraisals are challenging because subjective responses systematically differ due to cultural and social variances (10).
- Low birthweight: Is set at a maximum of 2500 grams, regardless of gestational age. The number of low birthweights is expressed as a percentage of total live births.
- Incidence or prevalence of specific diseases or conditions: Including communicable diseases (acquired immunodeficiency syndrome, pertussis, measles, hepatitis B), cancer and injuries in road traffic accidents (108–111).
- Absence from work due to illness: Expresses the amount of work days lost per year due to illness per working individual. It is a self-reported measure and excludes maternity leaves (112).

2.3 Health expenditure

Expenditure on health corresponds to the current expenditure on health (care) account, and stands for the final consumption of health goods and services by resident units (households, government and non-profit institutions), including goods and services for individual persons (curative care, rehabilitative care, long-term care, ancillary services and medical goods) along with collective health care services (prevention and public health services, as well as governance and administration of the health system) (9).

Health spending is influenced by a number of factors, across time and locations, including economic wealth and its growth (113–117), technological progress (118–120), demographic transition, led by increased longevity, and by increased number of those with increased longevity (121–123), imperfect competition (124–128), and an interplay of factors like health resources and utilization (such as provider payment models, the role of primary care, share of in-patient care, and public provision of care) along with other macro social and economic variables (such as labour market changes, unemployment, the share of immigrants, the size of parliament and the share of women in parliament) (129,130). As Busse, Ginneken and Normand (2012) summarized, growth of health expenditure derives from two fundamental changes: higher unit costs for the existing volume of services, and modifications in patterns of service use. These derived from ageing, demographic transition, economic growth, new technologies, organization and financing of the health system, and expectations of populations (131). Public health

spending, on the other hand, has been associated with GDP, and other macro social and economic factors like dictatorship, income inequality, and ethnic heterogeneity, along with demographic factors, like population over 60 year (132,133).

Financing this expenditure is a consecrated core building block of health systems (134–137), many are the goals that revolve around financing, from protection against the financial cost of ill-health to fairness (138), serving as the basis for universal health coverage while ensuring the collection of revenue, pooling of funds and the purchase of services (139). According to Mossalios and Dixon (2002) (140), financing the health care system congregates three functions that may be integrated or executed by differing parties: collecting revenue, pooling funds, and purchasing care, Likewise, according to System of Health Accounts (2017) (9), that sets definitions of expenditure data collected by OECD, financing schemes congregate the arrangements through which health services are paid and obtained by individuals, directly or through third-parties. According to this mechanism, such arrangements are marked differently by four characteristics: the mode of participation, from compulsory to voluntary; the basis for entitlement of benefits, a reflection of conditions for access to care that range from non-contributory, to contributory and discretionary; the way funds are raised, from compulsory to voluntary; and the extent to which pooling is possible, varying from inter-personal to non-inter-personal. These traits allow us to differentiate among the schemes.

A first set included government and compulsory contributory health care financing schemes established to guarantee access to health care goods and services under public programs to all individuals in a country, specific or vulnerable groups (9). The most relevant schemes comprised in this category are the following:

- Government health care financing schemes: Apply automatically to all resident citizens (being universal in reach) or to a targeted group of the population. Are defined by law, with a dedicated budget and government responsible body. Entitlement to benefits is due on non-contributory basis and, therefore, not linked to specific contributions made in the past. Pooling of funds is inter-personal, either geographical or program-related (9). Funds are compulsorily raised mainly by taxes, may they be direct or indirect, national or local, general or hypothecated. Taxes may also be used to transfer funds to other schemes. Direct taxes are usually progressive and allow redistribution (140).
- Social health insurance: Is mandatory, either for all citizens or addressed at specific groups set by public law, though eligibility for social insurance is not always automatic. Access to care is done on a contributory basis, by or on behalf of the person insured. Funding is raised through compulsory health insurance, detached

from risk, and some contributions may be paid by the government on behalf of non-contributing population. The inter-personal pooling of funds is based on geography or related to specific interventions (9). With a nature similar to an earmarked payroll tax, revenue from social health insurance is better protected from political interference, since collection and budgetary and spending decisions are entrusted to independent (140) though quasi-public bodies, close proximity to government (141).

- Compulsory private health insurance: Is also mandatory for citizens or specific groups of the population, as set also by proper public law. Entitlements are individually estimated, based on individual contributions and framed by the purchase of insurance from a selected agent. Funds are raised compulsorily and may involve tax credits. Pooling may be national, regional or scheme-centred, and may be contingent on risk equalization instruments, regulation of premiums and the normalization of benefits across schemes (140). Currently, these schemes are relevant in only three countries in OECD, Switzerland, The Netherlands and the United States of America (142).

On the other hand, voluntary health care payment schemes and other out-of-pocket payments provide optional care according to the will of private individuals or agents, with mostly limited or none inter-personal or inter-temporal pooling (9). These two forms of financing care have the following traits:

- Voluntary health insurance schemes have a contributory origin with entitlements based on the health insurance policy purchased. Funding is generally linked to risk but not to income. Government may support voluntary schemes with subsidies. Pooling is possible at scheme level, among subscribers (9). Private health insurance can be classified as i) substitutive, set as an alternative to public coverage; ii) supplementary, focusing on quicker access and higher comfort; or iii) complementary, offering a specific degree of coverage for services excluded from public offer. Premia are generally based on the individual's risk, and are collected by private for-profit or non-profit agents (140).
- Household out-of-pocket expenditure: represents the direct financial burden of health for households, potentially catastrophic. Are voluntary by nature and depend on the will and ability to pay of individuals. They solely depend on contributions made to pay for services. Funds are gathered by the household's available income and savings. Pooling mechanisms extend no further than to the household (9). These include i) direct payments, excluded from any of the previous forms of insurance, for services rendered mostly by private carers; ii) formal cost sharing, through user charges, a

debatable tool to contain demand with impact on equity, and iii) informal payments, not endorsed by the system, untransparent, and generally illegal (140).

The System oh Health Accounts (2017) foresees the existence of four other schemes with very little weight on total financing in OECD: compulsory medical saving accounts; non-profit institutions financing schemes; enterprise financing schemes (other than employer-base insurance); and ROW financing schemes (9). Mossalios and Dixon (2022), also consider external sources used mainly in low and middle-income countries, including donation from non-governmental organizations, transfers from donor agencies and loans from international banks (140).

2.4 The link between health outcomes and health expenditure

Studies focusing the association between health outcomes and health expenditure have been performed on various locations, from OECD and European countries, to specific countries like the United Kingdom or the United States, or even focused on global-scale cross-country comparisons. Input measures concentrating on health expenditure, along with other health determinants, have been matched against a considerable range of health outcomes. Inputs covered areas like health and social, along with public (or government) and private spending, spending per type of health service or goods provided, per type of resource used or per level of care, with differing measures being used, like per capita, proportion of GDP, or proportion of total, government, and social spending. Health determinants used as covariates considered national income, environment and other context-specific indicators, socioeconomic status, demographic profile, and lifestyle and behaviour. Health outcomes comprised an equally wide range of mortality and morbidity measures, per gender or age, such as total, cause-specific, infant and maternal mortality; life expectancy; potential years of life lost; avoidable mortality, total or from specific causes; low birth weight; and risk factors such as obesity, asthma, mental illness, or limited activity.

OECD and Europe

Elola, Daponte and Navarro (1995) studied the association between health care systems and health outcomes in 17 European countries with national health services and social health insurance systems. When comparing health systems, GDP and health expenditure were the only two indicators reaching statistical significance in their link to health. The work showed that health expenditure was negatively related with potential years of life lost for females (explaining 32% of cross-country variability) and infant

mortality, while a positive link was observed with female life expectancy (explaining 37% of cross-country variability). Apart from GDP, no other socioeconomic measure explained outcomes significantly. Health expenditure was not associated with outcomes for males. At similar levels of GDP and health care expenditure, infant mortality was observed to be lower for health systems with national health services (143). Further at the turn of the millennium, Cochrane, St Leger and Moore, while seeking to explore which variables could explain differences in mortality in 17 developed countries, concluded that the proportion of care financed by public expenditure was negatively associated with mortality, especially for age groups of 15 to 24 and 25 to 34 (144). Or (2000) assessed the effectiveness of health care inputs upon potential years of life lost, in 21 OECD countries, from 1970 to 1992, attempting to dismantle the relative effect of contextual, medical, social and economic factors. Inputs accounted for medical variables (health expenditure) and non-medical variables (such as physical environment, lifestyles, and socioeconomic factors). Health expenditure and fat consumption had a significant relationship on opposite directions with men's health outcome. Pollution and fat consumption were the two factors that significantly and positively explained potential years of life lost for women (145). Using data from 15 countries of the European Union from 1980 and 1995, Nixon and Ulmann (2006) measured the association between three outcomes of health (life expectancy for men and women, and infant mortality), and input measures of health system, lifestyle, and environmental nature (including total per capita health expenditure, weight of health expenditure in GDP, number of physicians, number of hospital beds, in-patient admission rates, average in-patient length of stay, coverage of the health system, unemployment rate, alcohol consumption, expenditure on tobacco, protein per capita, and environmental pollution). Education and other country-specific determinants of health were also included. Male life expectancy was positively associated with health expenditure, number of physicians, nutrition and pollution, while women's life span and infant mortality were determined by the first two variables, with great heterogeneity of results among countries. Association between health expenditure and infant mortality was significant and stronger than that with life expectancy, with expenditure explaining over 78% of the outcome. Country-specific characteristics included in the model were the most relevant contributors to life expectancy, explained around 94% of male and female indicators, with health expenditure marginally accounting for only 2.6 and 2.8 years on total average years of life (146). In 2011, Bradley and colleagues studied the association between health outcomes and expenditures with health and social services, for OECD countries, from 1995 to 2005. Health outcomes included life expectancy at birth, infant mortality, low birth weight, maternal mortality and potential years of life lost. Health care expenditure measured public and private spending

on curative care, rehabilitative care, long-term care, ancillary services (like diagnostic imaging, laboratory tests and patient transport), outpatient medical goods, prevention and public health services, health administration and insurance, and capital expenditures, along with health education and training, health research and development, and long-term care services for people with functional limitations. Countries spent between 20 to 35% of their GDP on both expenditures, although mixes varied considerably. The ratio of social to health spending averaged 2 in Europe but less than 1 in the US, and proved to be significantly related with better life expectancy, infant mortality and potential years of life lost, but also with lower birth weight. Health care spending as a percentage of GDP was associated with better life expectancy and maternal mortality. Social expenditure' share was linked to better life expectancy, infant mortality and potential years of life lost, but also to lower low birth weight. Both expenditures considered together produced no significant results. Evidence indicated that reforms to improve health status should also focus on social services (147). Also, Heijink, Koolman and Westert (2013) assessed the marked relationship concerning avoidable mortality from specific causes, and the growth of health care spending, but this time in 14 western European countries, between 1996 and 2006. Avoidable mortality, per year, declined by 2,6–5,3%, while at the same time, spending rose by 1,9-5,9% per year, with countries with above-average spending recording above-average reductions in the outcome. Mortality from circulatory system diseases explained the greatest part of the total avoidable mortality reduction in all countries. Contemporaneous and lagged health expenditure showed a significant association with avoidable mortality, but time trends reduced such impact. Even after controlling for socioeconomic, lifestyle and demographic confounders, like the weight of population older than 60, unemployment, proportion of population with lower-level education, tobacco and alcohol consumption, the association between spending and avoidable mortality remained. Education and lifestyles were not significant in explaining avoidable mortality, emphasising the role of health care in health (148). Kim and Lane (2013) focused on the relationships between government health expenditure (as a percentage of total health spending) and two health outcomes, infant mortality and life expectancy at birth, across 17 OECD countries, from 1973 to 2000. Socioeconomic determinants of health were also represented though real GDP per capita, Gini coefficient, unemployment, and population over 65. Researchers found significant associations, with public health spending positively linked with life expectancy, but negatively with infant mortality. A 1 percent increase in spending would give raise to a 0.077 decrease in infant mortality and a 0.026 percent increase in life expectancy at birth, after controlling for covariates in each country, proving that public spending on health is a good predictor of health outcomes

(149). A study conducted by Budhdeo and colleagues (2015), among countries of the European Union, between 1995 and 2010, examined the link between 1) inputs such as changes in health spending as a proportion of total government expenditure, government health care spending as a fraction of GDP, and government spending per capita, and 2) population mortality, as measured by neonatal mortality, post-neonatal mortality, 1-5 years of age mortality, under-five years of age mortality, adult male and female mortality. The study showed that decreasing only 1% in government health spending was associated with a significant increase in all six mortality measures. The same impact was derived from the other two measures of expenditure. Significant effects of reducing spending were seen as having enduring effects on health, affecting all mortality metrics, not only in the short term but also in the longer run, for at least five years (150). Mackenbach and colleagues' study from 2017 of 17 European countries, from 1980 to 2010, focused on the association between health care expenditure and amenable mortality. Along with national income per capita, the study included education, which stood for socioeconomic status, allowing an analysis on educational inequalities in mortality. The study included around 23 conditions amenable to care. Inputs of interest included per capita health care spending, health care spending as a percentage of GDP, per capita public health care expenditure, public health care expenditure as a percentage of GDP, and private households' out-of-pocket spending on health as a percentage of total health spending. Although declining over time, deaths due to amenable causes summed up to over 2 million for the three decades under analysis, totalizing over 750 million person-years. Although larger, amenable mortality for those with lower education decreased slightly faster than that of those with higher education. With regards to education, absolute inequalities showed to be stable across time, while relative inequalities grew deeper. National income was significantly and negatively associated with amenable mortality. Higher health care expenditure was linked with lower amenable mortality, but not with lower mortality from non-amenable causes. In relative terms, health spending affected amenable mortality among those with lower and higher education alike. Increased spending on health was associated with a reduction of absolute inequalities in amenable mortality (151).

Summarising the findings above, it is possible to observe that, with a single exception, studies conducted with OECD and European countries pointed to a statistically significant and positive relationship between health expenditure and health outcomes. Spending either as per capita, as a share of government expenditure or as a share of GDP, proved to be negatively associated with infant, child, maternal and adult mortality, potential years of life lost and avoidable mortality, while positively associated with life

expectancy. Likewise, increased public/government health spending, either per capita, as a share of total health expenditure or as share of GDP, showed to be related to increased life expectancy, and reduced infant and other age-specific mortality. When compared to social spending, health expenditure showed to be less effective in improving life expectancy, infant mortality and potential years of life lost. Relationships with outcomes proved to be significant for covariates such as the country's wealth, pollution, education, nutrition, lifestyle and behaviour, health care resources. GDP showed to explain outcomes to a substantial extent.

Within-country research (UK, US and Canada)

Relative to the United Kingdom, Martin, Rice and Smith (2008) assessed how public health expenditure on programmes of care for cancer and circulatory diseases, set by local health authorities, in the UK, including spending with inpatient, outpatient and community care, along with pharmaceutical prescriptions, related to health outcomes for the financial year 2004/2005, showing a strong and positive impact of spending per capita upon amenable mortality for those aged 75. Positive correlations were found, though weak, between spending and amenable mortality for the two conditions. However, adjusting spending for local health care needs according to the demographic profile of primary care, showed the opposite result. Modelling outcomes according to the level of expenditure of each primary care centre that maximizes total welfare, the local need for health care, and environmental factors, reveals that a 10% increase in cancer expenditure per capita entails around 4.9% reduction in the number of cancer deaths and 37.8% reduction in years of life lost. Circulatory diseases outcomes proved to be more responsive to expenditure, with a similar increase in spending generating a 14% reduction in death rates and a parallel reduction in years of life lost (152). Later, in 2017, Watkins and colleagues estimated the impact of reductions in the English public spending on health and social care upon mortality, for the period between 2001 and 2014, through times trends analysis that compared actual outcomes for 2010-2014 with rates based on trends before constraints started. Outcomes included population mortality, life expectancy, and potential years of life lost. Spending restrictions were associated with over 45,000 higher-than-expected deaths from 2012 to 2014, with the major portion streaming from mortality for individuals aged over 60 years and in-home care. Deaths in hospitals were found lower than expected. The number of potential years of life lost due to amenable causes was higher than the estimate by previous trends, while for life expectancy the number was lower. Public spending with social care was

more strongly related with home and care home mortality than spending with health care. A reduction of 10 GBP of social care spending per capita was linked to a raise in care home mortality of 5.1 per 100,000, while a similar reduction in health care spending would only reach 0.19. Spending on social and health care remained inversely associated with care home mortality, after macroeconomic factors were considered. Moreover, the number of NHS hospital and community nurses, and NHS health and social care clinical support staff were both negatively associated with care home mortality (153). In 2018, Claxton, Lomas and Martin, researched the association of England's health expenditure with all-cause and disease specific mortality, from 2003-2010. Results showed that a 1% increase in spending per capita was linked with a 1.089% reduction in mortality (154).

In the US, in 2003, Fisher and colleagues conducted two studies relating end-of-life spending, a proxy of expenditure that was expected to overcome differing levels of spending across states streaming from levels of ilness and prices to disease specific measures of utilization of resources and measures of health status. The team showed that differences in expediture were defined by inpatient and specialist-based patterns of practice in higher spending states, but were not linked with better quality, access, satisfaction nor by outcomes (155,156). Concentrating in Public Health, Mays and Smith (2011) conducted a study to assess if changes in spending during 30 years, by local Public Health agencies, contributed to changes in community mortality from preventable causes. Health outcomes included infant mortality and deaths due to cardiovascular disease, diabetes, and cancer. A 10% increase in local public health spending was found to decrease mortality rates between 1.1 and 6.9 percent, proving that the field of expertise of Public Health is able to strongly contribute to health gains (157). In 2016, in the US, Bradley and colleagues estimated the association between state-level health outcomes and state-level allocation of spending in Public Health and Social Services, for the period of 2000-2009. State-level outcomes included adult obesity, asthma, mental illness, and limited activity, along with post-neonatal mortality and mortality from acute myocardial infarction, type 2 diabetes, and lung cancer. The input variable focused on spending on Social Services and Public Health relative to total spending on health care by Medicare and Medicaid, representing the ratio between expenditure on services that aimed at social determinants of health in relation to expenditure on services that aimed at the medical determinants of health. Data was controlled for socioeconomic and demographic characteristics. Expenditure, outcomes and the ratio of social services and public health on health care spending varied greatly across states. The study found that states with greater portion ratio had significantly better health outcomes on adult obesity,

asthma, mentally unhealthy days, days with limited activity, and mortality for lung cancer, acute myocardial infarction and type-2 diabetes. Increased social services and public health spending, as a percentage of state-level GDP, was associated with improved outcomes for all outcome measures, and with significant associations with mentally unhealthy days, days with activity limitations, and mortality from lung cancer. Also, increased spending on health services as a percentage of income worsened all health outcomes, being significantly associated with worse adult obesity, asthma, mentally unhealthy days, days with limited activity, and death from lung cancer (158).

Focusing in 10 Canadian provinces, Crémieux and colleagues (1999) studied how health spending affected life expectancy and infant mortality, showing that the variables were in fact statistically associated, despite economic, demographic, nutritional and behavioural confounders, with the overall effort to ensure access to care and quality as central traits of enlarged spending (159). Dutton and colleagues (2018) led a study similar to that of Bradley (2016), in nine Canadian provinces, between 1981 and 2011. The ratio of social to health spending was used as input, while dependant outcome variables were avoidable and infant mortality, along with life expectancy at birth. Age, gender, urban/rural, population size, unemployment, income, the Gini coefficient and total real provincial expenditure were also controlled for in the study. Research found that health outcomes trended favourably overtime, showing improvements in all provinces, while spending rose. A 1% increase in the combined ratio of social to health spending alone was associated with a 0.1% decrease in potentially avoidable mortality, and a 0.01% increase in life expectancy. The link to infant mortality was non-significant. A similar growth in health spending showed to give rise to a residual 0.064% increase in potentially avoidable mortality, while life expectancy remained unalterable. When such growth was applied to social expenditure, potentially avoidable mortality would decrease 0.034%, and life expectancy would increase 0.006%. A 1-percentage point increase in unemployment was associated with a 2% increase in infant mortality and a 0.67% increase in potentially avoidable mortality. Larger populations were linked with better infant and potentially avoidable mortality outcomes, while a rural population was associated with the opposite. Higher median income and real public spending were linked to worse avoidable mortality and life expectancy (160).

In short, studies focusing on Canada and the UK, revealed the same trends. In the case of Canada, health expenditure per capita showed to be linked to life expectancy, infant mortality, years of life lost, and, when compared to social expenditure, it also proved to be related to life expectancy and avoidable mortality, however with smaller impact too. Unemployment, demographics, nutrition, and behaviour explained outcomes

substantially. Meanwhile, in the UK, local primary care spending per capita was inversely related to all-cause mortality, avoidable mortality, and years of life lost, while disease-specific spending showed to have a considerable impact in disease-specific avoidable mortality and years of life lost for cancer, circulatory, respiratory and gastro intestinal conditions. When compared with social services, health expenditure per capita followed the trend observed earlier, displaying, once more, a much weaker bond with mortality. Macroeconomic determinants did not alter these associations. When it comes to the US, expenditure as a share of GDP was negatively associated with obesity, asthma, mental health, disability, and disease-specific mortality, while expenditure on local Public Health services with health promotion and disease prevention was negatively linked to mortality, along with education, income and race. When considered in combination, health and social services expenditure, addressing mostly the social determinants of disease, were significantly associated with mental health, disability, and disease-specific mortality.

Global cross-country comparisons

Back in 1996, Musgrove analysed in 69 low, middle and high-income countries, the impact of education, GDP, health expenditure, government health spending and out-of-pocket spending on disease-specific mortality, showing that public health spending was more effective in increasing life expectancy than private expenditure on health, while public financing was especially critical for poorer nation. In these countries, spending on health was loosely related to better health status, in turn more dependent on broader environmental factors. The study could not favour government over private expenditure despite of what is being financed, but did stressed the role of adequate public expenditure to ensure that valuable public health interventions are provided (161). When examining the impact of public spending in health and non-health factors (economic, educational and cultural) in under-five child and infant mortality for WHO countries, Filmer and Pritchett (1999) found that the first was numerically and statically not significant. Income per capita, inequity of income distribution, female education, ethnic fragmentation and religion playing more significant roles (162). Zakir and Wunnava (1999) also addressed the relation of government health expenditure as share of GDP to infant mortality in 117 countries, during 1993, showing that fertility, female participation in the labour market, female literacy had a negative and significant impact on the outcomes, contrary to health spending (163). Bokhari, Gai and Gottret (2007) assessed elasticity of under-five and maternal mortality, in relation to government health expenditure, for 2000. The model accounted for the effect of other variables, like GDP per capita, public health expenditure, education, sanitation, roads and donor funding.

Mean elasticity of under-five mortality to government expenditure was -0.33, while that of maternal mortality was -0.5, both negative and statistically significant, evidencing that government health expenditure improved health outcomes, although with variations across developed and developing countries. Likewise, a reduction in illiteracy and an increase in paved roads also reduced under-five and maternal mortality (116). In 2013, Farag and colleagues researched the relation between total and government spending, and health outcomes in 133 low and middle-income countries, for the years 1995-2006. Outcomes included infant and under-five child mortality. Educational and other socioeconomic, demographic, health system and contextual control variables were also considered. Government spending was also assessed with regards to a measure of governance effectiveness set by the World Bank. Wide cross-country variations were observed in outcomes and inputs. Income was found negatively associated with infant mortality, but disparity of outcomes for countries at similar income levels pointed to the role of additional variables. Income and health spending per capita, along with female education were found negatively related with infant and child mortality, while fertility had a positive impact on both dependant variables. Health expenditure was found to have a significant impact in decreasing both outcomes, with 1% increase in spending originating a reduction of 0.13% in infant mortality, and of 0.15% in child mortality. Income per capita allowed a reduction in infant and under five mortality rates of 0.58% and 0.64%. Public spending was found to also be a significant determinant of outcomes, strongly moderated by the level of government effectiveness, underlining the role of sound institutional practices in the health of individuals (164). In 2014, Jaba, Balan and Robu too reviewed the association between health spending and outcomes, for 175 countries, grouped per geography and income, between 1995 and 2010. The input considered was per capita health expenditure, while the outcome was life expectancy at birth. Across income groups, the European region, with a high proportion of developed countries, showed the highest level of health expenditures compared to all other regions, along with the highest differences among countries. Developed countries also had the highest life expectancy. Middle-income countries achieved the strongest effect of spending on outcomes, while higher income groups obtained the smallest. Health expenditure had the highest impact on the outcome in countries of the South-East Asia Region, with the opposite effect felt by the European Regions. Considering life expectancy as a function of spending, a significant association was found between both variables across countries by level of income or geographic position. Country-specific effects were significant, either by level of income or by geographic position, and expressed relevant dissimilarities in the outcome of interest among socioeconomic groups (165).

Regarding global cross-country comparisons, observations also point to a link between expenditure and outcomes like life expectancy, infant and child mortality and maternal mortality. Although early studies indicated a null impact of total and public expenditure on health upon life expectancy and mortality and to the substantial impact of income and education, contemporaneous research shows otherwise when comparing the link across developed and developing countries. The association has proven health expenditure per capita and government/public spending per capita to be negatively linked to infant and child mortality, with results proving to have slightly different impacts for countries in different levels of development. Middle-income countries appear to benefit from the largest effects of health expenditure on health, while there seems to be a convergence around good outcomes in high income countries. Public expenditure appears to ensure highly needed and effective Public Health interventions in poorer countries, where environmental determinants beyond health care matter most, and factors like infra-structure, education, income, female labour participation, along with institutional effectiveness, have a salient role in explaining health outcomes overall.

3. Data and methods

3.1 Data

In order to capture the most recent, and therefore relevant, epidemiological and macroeconomic context and updated medical practices, this dissertation is developed using data from all OECD countries, between 2002 to 2017. OECD is an international organization that provides information and advice to support decision making and the construction of policies, based on regularly collected and harmonized socio-economic data. Currently, OECD congregates the following 37 countries:

. Australia	. Estonia	. Israel	. Netherlands	. Sweden
. Austria	. Finland	. Italy	. New Zealand	. Switzerland
. Belgium	. France	. Japan	. Norway	. Turkey
. Canada	. Germany	. Korea	. Poland	. United Kingdom (UK)
. Chile	. Greece	. Latvia	. Portugal	. United States (US)
. Colombia	. Hungary	. Lithuania	. Slovak Republic	
. Czech Republic	. Iceland	. Luxembourg	. Slovenia	
. Denmark	. Ireland	. Mexico	. Spain	

Data on all variables for these countries was collected from the online statistical platform of the OECD. Themes were explored and four datasets were used to collect data on the all variables of interest (166):

. All dependent variables were collected from theme Health, in dataset Health Status
. All independent variables were collected from theme Health, in dataset Health Expenditure and Financing
. Elderly population was collected from Health, in dataset Demographic References
. All covariates except Elderly population were collected from theme General Statistics, in dataset General Statistical Archives - Country Statistical Profiles

3.2 Variables

Dependent variables

Health outcomes used in this dissertation will focus on mortality-related variables. This will avoid the disadvantages of morbidity measures, including their lower standardization, irregular and scarce collection, detachment from the effects of the health system, and their direct link to the respondent's expectations. Four outcome variables will be considered. First, standardized mortality. A generic indicator, standardized mortality has a long history of consistent collection and has proved to be a reliable and available

measure, which facilitates comparisons across countries. It is expressed as the standardized number of deaths per 100,000 population, irrespective of cause, and denoted as “Deaths”.

Second, potential years of life lost. A health gap measure, it indicates premature deaths believed to be preventable, and is the difference between a chosen limit of 75 years for the population as a whole, and actual mortality results. Potential years of life lost are expressed as the number of years lost per 100,000 population, until aged 75 years, also regardless of cause and referred to as “YLL”.

Finally, avoidable preventable and treatable mortality. Avoidable mortality is an indicator largely known for accounting for the role of the health system in decreasing the number of deaths from specific conditions, which incorporates two subset measures: preventable mortality and treatable (or amenable) mortality. The preventable portion relates to those conditions that could have been averted by public health and primary population-centred interventions, before the inception of disease. The treatable part, in turn, considers those conditions that could have been positively influenced by timely and effective care, after the onset of disease. Both measures are expressed as the standardized number of deaths per 100,000 population, regardless of their causes. Preventable mortality will be denoted as “Preventable Mortality” and Treatable as “Treatable Mortality”. Data on preventable and treatable mortality became available since 2002, a condition that constrained the time period under analysis in this study.

Independent variables

Despite potential differences in data reported as mentioned by each country’s notes on sources and comparability on OECD Stats (142), two explanatory variables will be used in this study. First, health expenditure. As defined earlier, it stands for the total final consumption of health goods and services by resident units, including goods and services for individual persons along with collective health care services. It encompasses sums up all financing schemes at work in each country and is measured per capita, at current prices and current purchasing power parity, in US dollars. Will be denoted as “Health Exp pc”.

Second, government and compulsory contributory health care financing schemes, that ensure access to health care within public programs, to the whole of society in a country or to particular and vulnerable groups. It stands for schemes that are defined and set by law, with funds collected compulsorily. These financing schemes will be expressed per

capita, at current prices and current purchasing power parity, in US dollars. Will be referred to as “Public Health Exp pc”.

Covariates

Because health is not determined solely by the amount of funds injected in health system and their nature, either public or private, the relationship between the above health expenditure and health outcomes will also contemplate five other variables that represent additional levels of determinants and potential confounding factors, namely the structural environment, material and social conditions, individual lifestyle and demographic factors:

- Gross domestic product: An aggregate measure of the production of a country, it is the most commonly used indicator of economic performance (167). Gross domestic product will be expressed in per capita terms, in US dollars at current prices and current purchasing power parity. Will be denoted as “GDP pc”.
- Unemployment: Is also a commonly used indicator that stands for economic and social well-being (167). It will be represented by the percentage of unemployed persons in the total labour force, which include the unemployed, the self-employed and those doing remunerated work. Will be referred to as “Unemployment”.
- Elderly population: Due to its substantial increase in the last decades, this group raises specific social and economic challenges for many regions (167). This aggregate indicator is measured as the percentage of those aged 65 years old and over in total population. Will be denoted as “Elderly Population”.
- Educational attainment: As globalization and technology develop, knowledge and skills of the population and the labour force are increasingly important (167). Educational attainment will be measured as the percentage of those aged 25 to 64 years of age with an educational level below upper secondary, which includes early childhood, primary, and lower secondary education. Will be noted as “Low Educational Attainment”.
- Smoking: One of the most important avoidable risk factor for health, smoking is associated with many causes of premature mortality, like cardiovascular disease and cancer (167). Smoking will be represented as the proportion of population aged 15 or above that reports smoking on a daily basis on total adult population. Will be referred to as “Smoking Daily”.

3.3 Statistical methods

Given the nature of data used in this dissertation, originated from twelve quantitative variables over fifteen years for all OECD countries, this will be a longitudinal panel data study (168). The statistical analysis followed in this dissertation entails three stages. First, it will cover univariate descriptive statistics, describing all numerical continuous variables with measures of location, which include central tendency, like the mean and median, and variability or dispersion, which consider the spread of data around the central value, like standard deviation, minimum and maximum (169,170). A graphical analysis of variables will be presented.

Second, in order to explore existing relationships between pairs of quantitative variables, bivariate analysis will be conducted covering the examination of scatterplots and Pearson's r coefficient of correlation. Scatterplots allow a first image of the relation between pairs of dependent and independent variables, and also between dependent variables and GDP, for its close link to health expenditure. Pearson's r accounts for the strength and direction of the relationship between each two of variables, varying from -1 to 1, with both values expressing perfect inverse and direct associations, respectively, and 0 expressing the inexistence of any relationship. These results will be presented in correlation matrixes including statistically significant links.

Third, analysis of multivariate relationships between variables was conducted using generalized linear models, as devised by Nelder and Wedderburn in 1972 (171), who, intending to demonstrate the unity of many statistical methods, developed a single procedure for fitting models based on the maximization of likelihood. Models involve three components: a) a random component, in which the dependent variable has a specific probability distribution from the exponential family; b) a systematic component, in which selected independent variables produce a finite number of unknown linear parameters; and c) a link function that connects the means of the expected values of the response to a linear combination of those explanatory variables (172,173). Knowing that the study's health outcomes are expressed as continuous data, the most adequate distribution for each dependent variable was investigated. A single model with Death as dependent variable, Health Exp pc as independent variable and GPD pc, Unemployment, Elderly Population and Smoking Daily as covariates was built with generalized lineal models using normal distributions with both identity and logarithmic link functions, and gamma distribution with logarithmic link functions. Logarithmic transformations are intended to produce results that are approximately normal, enabling model construction (172). Per outcome, the distribution and link function that generated the lowest Akaike Information Criterion (AIC) was selected. As observed in Table 1,

Gamma with logarithmic link function was the probability distribution and the link function that better described all four health outcomes.

Table 1: Selection of distribution and link function

Dependent Variable	Probability Distribution	Link Function	AIC
Deaths	Normal	Identity	3,043
	Gamma	Log	2,921
	Normal	Log	2,965
YLL	Normal	Identity	4,301
	Gamma	Log	4,026
	Normal	Log	4,123
Preventable Mortality	Normal	Identity	2,200
	Gamma	Log	1,941
	Normal	Log	1,989
Treatable Mortality	Normal	Identity	1,972
	Gamma	Log	1,704
	Normal	Log	1,793

Given the nature of longitudinal panel data involved, with indicators measured per country and overtime, the independence of observations per outcome measure cannot be assumed. For that reason, addressing multivariate relationships between selected variables was conducted using mixed models, a special case of generalized linear models that deals with correlation between observations of the same outcome, thus ensuring valid statistical inferences. OECD countries was considered the subject of such repeated measures. Country random effects were included. Interactions terms were not included, only main effects of variables. Four models were built per outcome variable, so that a a total of sixteen regressions were performed. Per outcome, four models were built covering the respective outcome, each independent variable at a time, with or without the effect of wealth (GPD pc), along with all covariates each time. Because all determinants are in logarithmic form, coefficients can be interpreted as percentage change in the outcome for a one-point increase in covariates. To facilitate interpretation of results, health expenditure variables per capita, both total and from public sources, and GPD per head, all of these measured in units of US dollars, were converted in thousands of the same currency. Due to a lack of longitudinal data, the covariate Low Educational Attainment was excluded from the multivariate analysis.

Statistical analysis was conducted using IBM SPSS Statistics version 26.

4. Results

4.1 Univariate descriptive statistics

Health outcomes

Over the period under analysis, all four health outcomes considered in the study show marked improvements. Table 1 shows that Deaths from all causes decreased 20.8% on average in OECD regions, from 1008 to 798 per 100,000 population, at an average yearly rate of 1.52%, while YLL until the age of 75 fell by an average 27.1%, to 4,774 per 100,000 inhabitants in 2017, at a pace of 2.07% each year. Mean Preventable Mortality of 199 and Treatable deaths of 112 per 100,000 inhabitants, in 2002, declined by 30.1% and 32.6%, respectively, over the whole period, and around 2.34% and 2.57% per year. Average decreases were steady over time, although slightly disturbed in 2012 and 2015 for the total number of Deaths, and in 2017 for all four outcomes (Figures 2.1 to 2.4; Table 2; Annex 1.1). Mean number of Deaths differed from the median by 5.9%, but more than double that amount for all other three measures. Furthermore, in 2002, standard deviation of observations obtained for countries in the sample represented 20% of the mean value of the number of Deaths from all causes, but also nearly double for all other three measures, a situation unchanged sixteen years later, in 2017. In 2002, per 100,000 population, outcomes ranged from 672 to 1,520 total Deaths, from 4,113 to 13,601 YLL, from 116 to 379 total Preventable Mortality, and from 63 to 230 total Treatable Mortality. Fifteen years later, all countries had gradually improved health outcomes. By 2017, the worst total number of Deaths had decreased to 1,143, and total YLL was around 8,849, while maximum Preventable and Treatable deaths were 251 and 153, respectively. The best achievement were 562 total Deaths and 2,994 YLL along with 68 Preventable and 44 Treatable deaths (Table 2). Outcomes observed also varied across countries. Boxplots considering minimum and maximum value, sample median, first and third quartiles, and outliers for all observations across time, per country, also show that those underperforming (like Estonia, Hungary, Latvia, or Lithuania) or overperforming (like Switzerland, Japan or Sweden) in the beginning of the period mostly maintained their position relative to others at the end of period. In the group of those underperforming, wide variations of each outcome variable are also visible (Figures 3.1 to 3.4). (For detailed values per year, please refer to Annex 1.1).

Health expenditure

From 2002 to 2017, Health Expend pc almost doubled, increasing 84.2%, up to an average of 3,767 US dollars per capita in 2017, across all OECD countries, at an average

pace of 4.18% per year. In 2003, the growth of expenditure reached 8.6% among OECD countries, slowing down to -1% in 2011, and increasing again all the reaming years at an average rate of 3.52%. Meanwhile, Public Health Exp pc reached its highest growth (7.3%) in 2008, but also decreased to -1% in 2011, going back to positive average growths of 3.9% per year during the remaining period, until 2017. In total, spending from public sources increased 83.5% from 2002 to 2017, reaching an average of 2,842 US dollar per capita in 2017 (Figures 2.5 to 2.6; Table 2; Annex 1.1). The medians of Health Exp pc and Public Health Exp pc differ noticeably from the respective means in 2002, a behaviour carried out until 2017. The maximum expenditure in health in OECD countries more than doubled, growing from 4,249 US dollars per capita in 2002 to 10,213 in 2017. The same was visible for minimum spending, which increased from 520 US dollars per capita in 2002 to 1,119 in 2017. On the other hand, the maximum amount spent per capita on health from public sources increased over time by 137%, from 3,528 to 8,349 US dollars, while the worse achievements ranged from 256 USD in 2002, to 556 in 2017, more than doubling in the period (Table 2). Health Exp and Public Health Exp also varied across countries each year. Boxplots show that, among OECD countries, the US is by far the leading spender, on total and from public sources, and the country with the widest variation in values. In general, those countries that spend the least per capita (like Chile, Colombia, Estonia, Korea, Latvia, Lithuania, Mexico, Poland, Slovak Republic, and Turkey) are also those that spend the least from public sources (Figure 3.5 to 3.6). (For detailed values per year, please refer to Annex 1.1).

Table 2: Summary Statistics - Health Outcomes and Health Expenditure

Year		Health Outcomes				Health Expenditure	
		Deaths per 100,000 pop	YLL per 100,000 pop	Preventable Mort. per 100,000 pop	Treatable Mort. per 100,000 pop	Health Exp pc (PPP, USD)	Public Health Exp pc (PPP, USD)
2002	N	37	37	34	34	35	36
	Mean	1,007.73	6,545.42	190.65	112.47	2,045.30	1,548.50
	Std. Deviation	198.59	2,435.15	74.54	43.66	1,041.47	836.36
	Median	966.70	5,608.20	162.00	96.50	2,065.13	1,660.58
	Minimum	671.70	4,112.80	116.00	63.00	519.98	256.35
	Maximum	1,519.60	13,600.90	379.00	230.00	4,248.81	3,528.17
2017	N	24	24	24	24	38	38
	Mean	798.55	4,774.10	133.33	75.83	3,766.56	2,841.68
	Std. Deviation	158.95	1,687.40	50.01	31.97	1,910.82	1,622.06
	Median	744.00	4,036.45	116.50	61.50	3,609.81	2,754.48
	Minimum	562.00	2,994.40	68.00	44.00	1,118.97	555.72
	Maximum	1,142.80	8,849.30	251.00	153.00	10,212.75	8,349.31
Total	N	575	575	557	557	589	590
	Mean	878.76	5,468.90	156.00	89.97	2,957.88	2,188.61
	Std. Deviation	190.70	2,147.33	65.42	39.94	1,597.38	1,241.72
	Median	827.00	4,757.00	133.00	76.00	2,758.07	2,089.70
	Minimum	562.00	2,990.30	68.00	40.00	509.68	256.35
	Maximum	1,519.60	13,762.60	399.00	230.00	10,212.75	8,349.31

Covariates (other health determinants)

Because of their varied natures, covariates present differing behaviours. With a mean value of 24,305 US dollars in OECD countries, in 2002, GDP pc grew by 78% until 2017, to 43,229 US dollars, increasing by 4% per year, with 2006 presenting the largest growth of 9%, and 2009 the largest decrease of 3% (Figure 2.7; Table 3). In 2002, GDP pc ranged from 6,595 (Colombia) to 58,709 US dollars (Luxembourg), while by 2017, maximum value had almost doubled, to 107,525 US dollars, and minimum grew over 120%, to up to 14,607 US dollars, with the same countries leading each direction of the range (Figure 3.7; Table 3). Unemployment fell 12% from 2002 o 2017, down to a mean rate of 6.7%. The behaviour of the Unemployment rate was not steady. From 2003 to 2007, a decrease in Unemployment was observed, at an average 5% per year. From 2008 to 2010, the trend reversed and Unemployment increased each year at an average of 16%, spiking at 41% in 2009. In the period between 2011 to 2017, Unemployment went back to annual decreases of 5% per year on average in the OECD region (Figure 2.8; Table 3). Minimum and maximum rates for the period were quite stable but varied across countries, ranging in 2002 from 2.8% in The Netherlands to 20% in Poland, and in 2017 from to 2.7% in Iceland to 23.5% in Greece (Figure 3.8; Table 3). The share of Elderly Population grew steadily by 1.52% per year on average, from 2002 to 2017, with a total increase of 25.5% in the period, up to an overall mean share among OECD countries of 16.8% in 2017. Growth was stable, varying from 1% until 2011 to 2% after thereafter (Figure 2.9; Table 3). The highest share of Elderly Population found among OECD countries was 18.7% in Italy by 2002, but additional 9 percentage points in 2017 in Japan. Mexico was the country with the lowest share of elders in both years, with rates varying from 5.2 to 7.1%, respectively (Figure 3.9; Table 3). Low Educational Attainment among those aged 25 to 64 years old was only measured once, in 2014, with nearly 95% of values missing relating to the remaining years. At that time, 23.6% of those in that age group had attended a maximum level of education below upper secondary, with observations ranging from raging from 6.8% in the Czech Republic to 66.3% in Mexico (Figure 2.10; Figure 3.10; Table 3). With 49% of observation missing, Low Educational Attainment decreased 40.7% from 2002 to 2017, from a mean of 24.12% to a mean of 14.3%, (Figure 2.11; Table 3). The maximum share of adults Smoking Daily found among OECD members decreased by 10.2%, from 29% in Norway in the beginning of the period, down to 18.8% in Germany in the end. Mexico was the country with the lowest adult population Smoking Daily in both years, with rates decreasing 7% over the period, from 14.6 to 7.7% (Figure 3.11; Table 3). (For detailed values per year, please refer to Annex 1.2).

Table 3: Summary Statistics - Covariates

Year		Covariates				
		GDP pc (PPP, USD)	Unemployment (%)	Elderly Population (%)	Low Educational Attainment (%)	Smoking Daily (%)
2002	N	38	30	38		19
	Mean	24,305.04	7.65	13.39		24.12
	Std. Deviation	11,114.95	4.16	3.67		3.91
	Median	26,649.07	6.34	14.50		25.00
	Minimum	6,594.67	2.76	5.20		14.60
	Maximum	58,709.02	19.93	18.70		29.00
2017	N	38	37	38		9
	Mean	43,238.84	6.73	16.79		14.30
	Std. Deviation	17,466.41	3.80	4.44		4.06
	Median	40,550.92	5.74	18.20		16.00
	Minimum	14,607.03	2.74	7.10		7.60
	Maximum	107,525.20	21.49	27.70		18.80
Total	N	608	569	608	33	311
	Mean	33,578.71	7.76	14.82	23.65	20.34
	Std. Deviation	15,386.41	4.06	4.16	15.46	5.30
	Median	32,251.72	6.98	15.55	18.45	20.40
	Minimum	6,594.67	2.24	5.20	6.81	7.60
	Maximum	107,525.20	27.47	27.70	66.30	40.00

Figures 2: Per year evolution of mean values of health outcomes and health determinants of interest

Figure 2.1

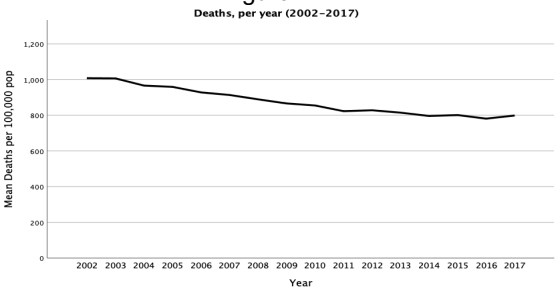


Figure 2.2

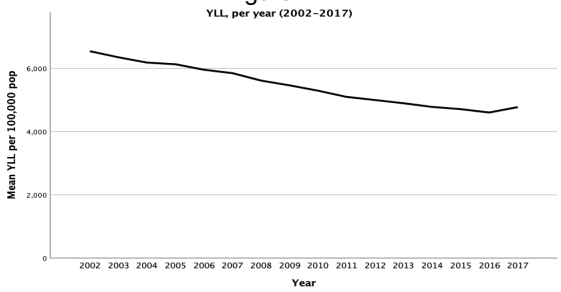


Figure 2.3

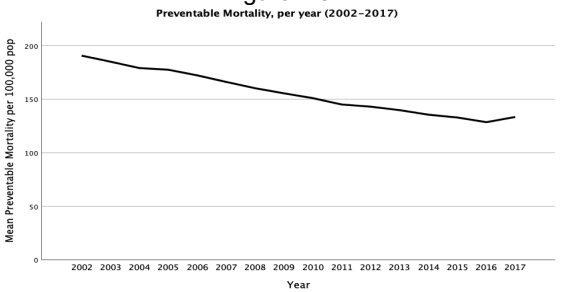


Figure 2.4

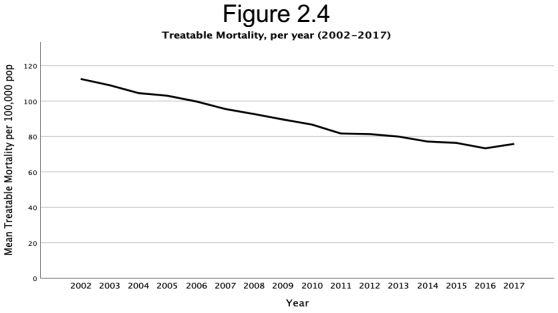


Figure 2.5

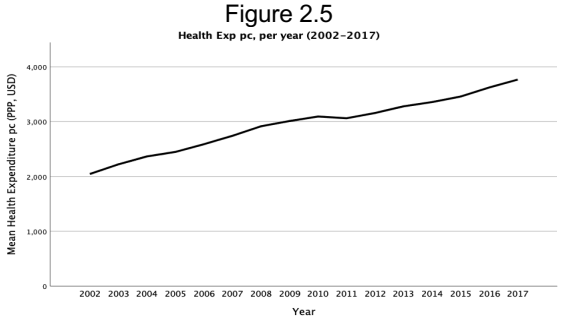


Figure 2.6

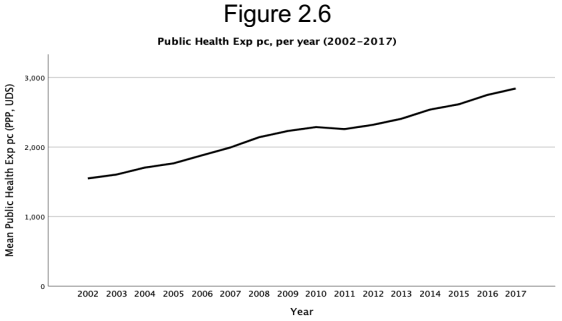
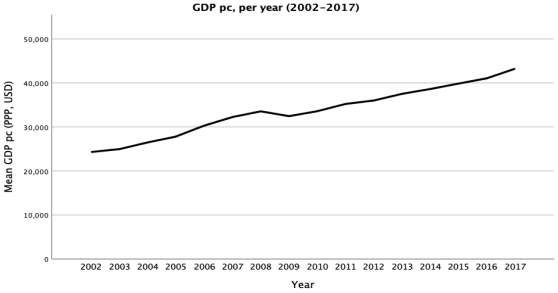


Figure 2.7



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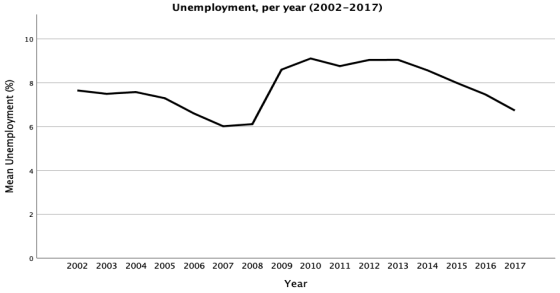


Figure 2.9

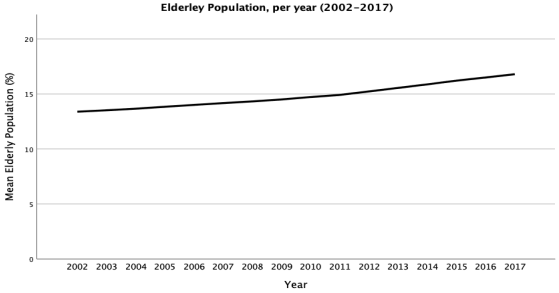
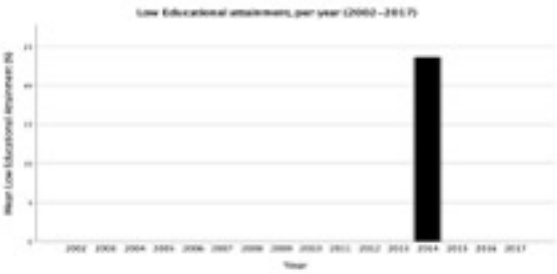


Figure 2.10



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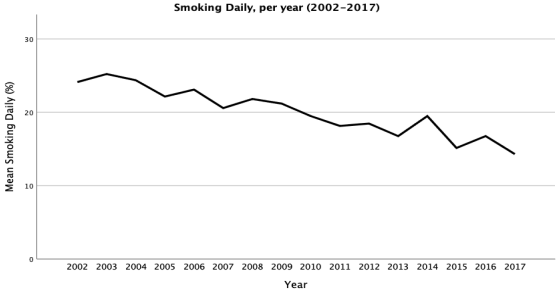


Figures 3: Health outcomes and health determinants per country

Figure 3.1

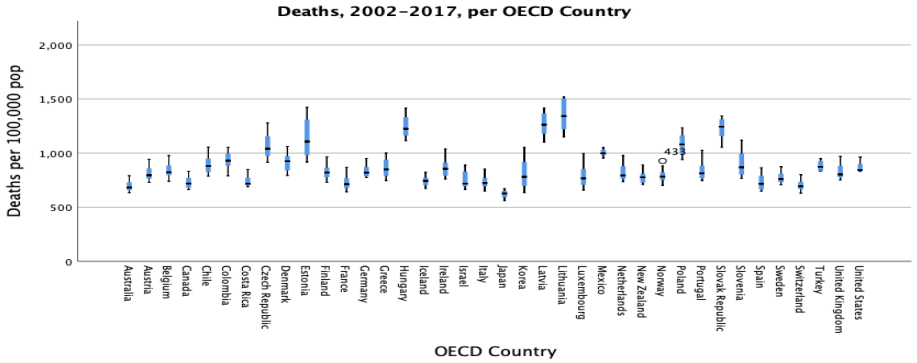


Figure 3.2

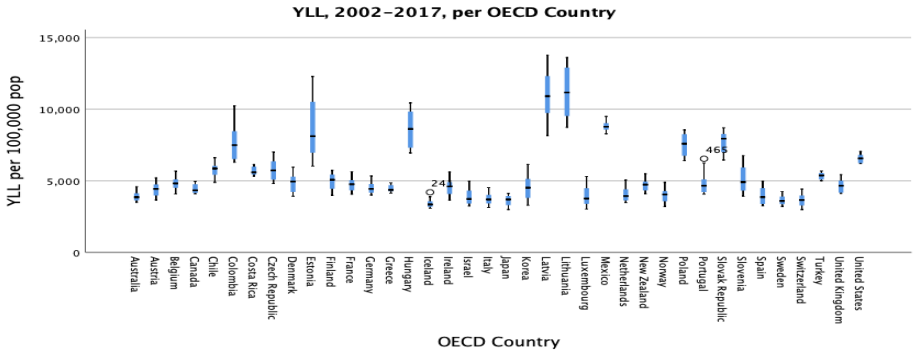


Figure 3.3

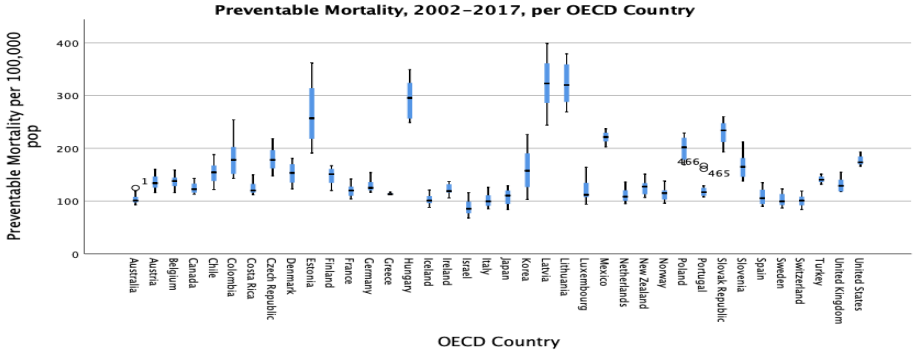


Figure 3.4

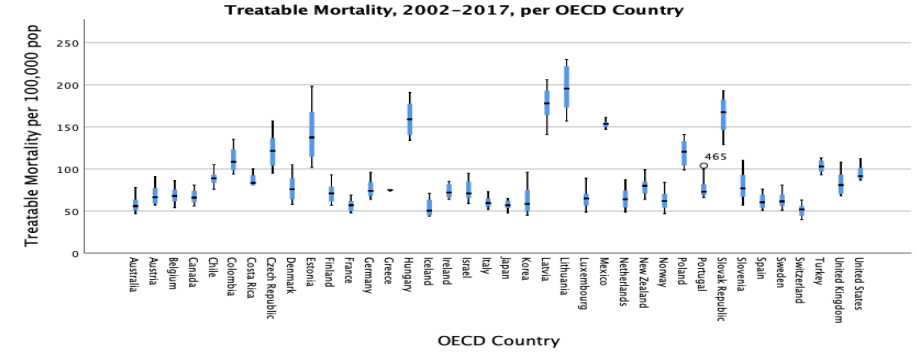


Figure 3.5

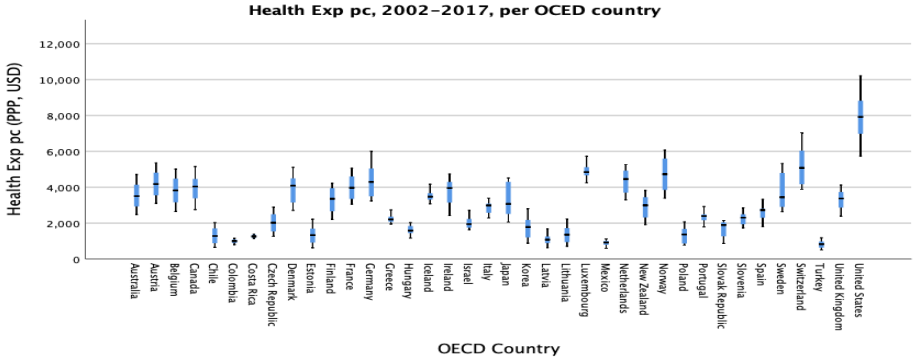


Figure 3.6

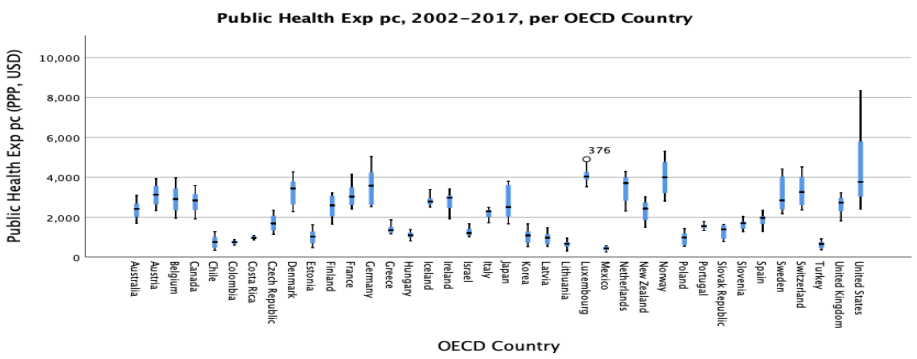


Figure 3.7

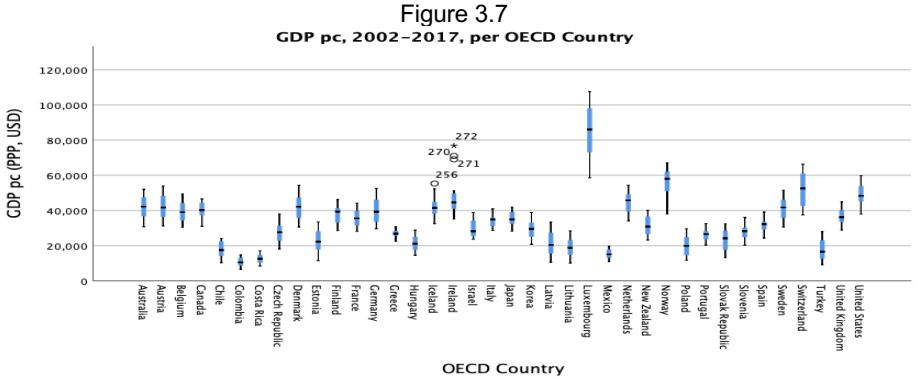


Figure 3.8

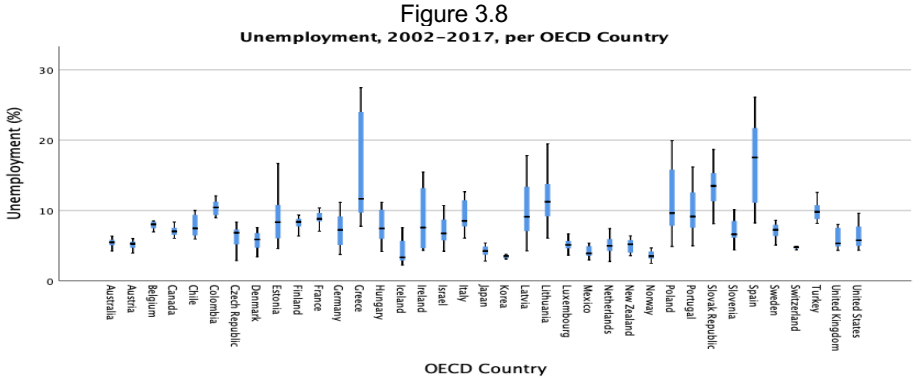


Figure 3.9

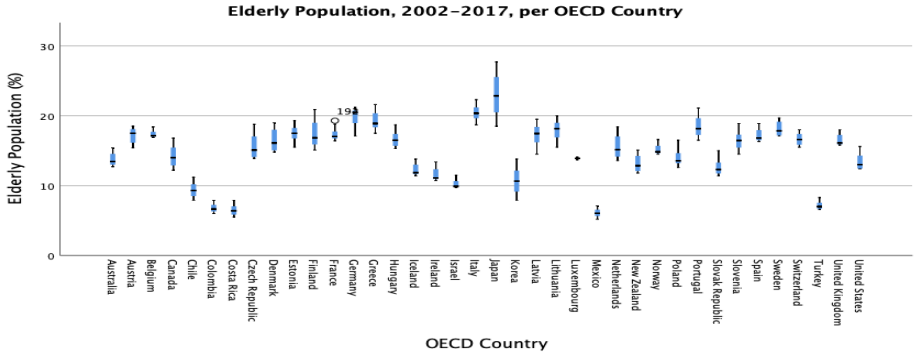


Figure 3.10

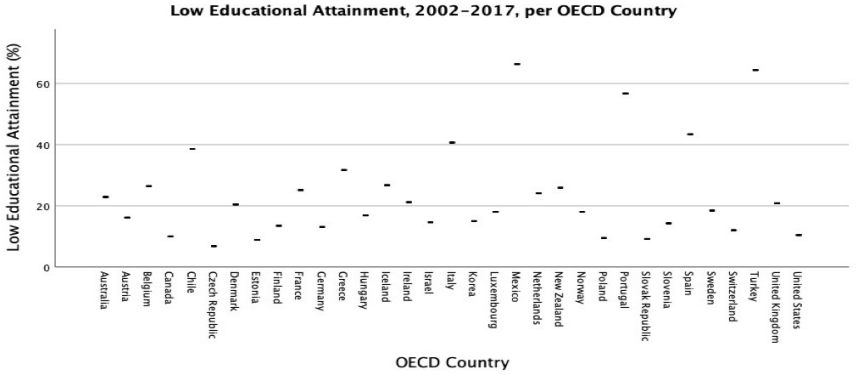
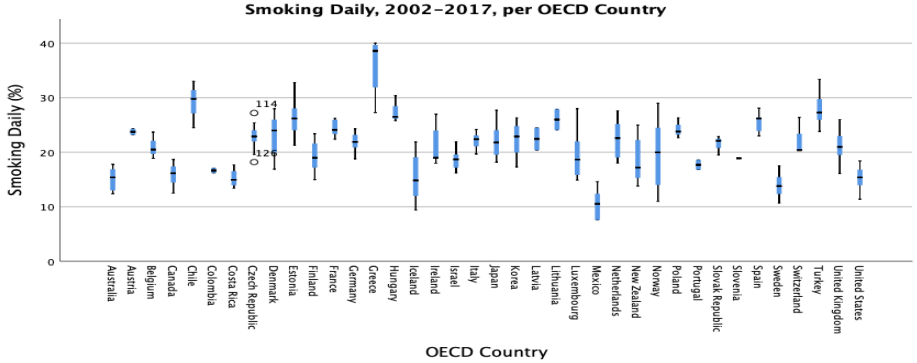


Figure 3.11



4.2 Bivariate descriptive analysis

Between outcomes and determinants

Graphical examination shows that Health Exp pc and Public Health Exp pc, measured, are negatively associated with all four dependent variables, both for 2017 and for the entire period of interest, 2002-2017 (Figures 4.1 to 4.8 and 5.1 to 5.8). In relationships for the entire period of analysis, the United States shows a link between outcomes and Health spending, total or public, unlike all other OECD members (Figures 5.1 to 5.8).

Correlation matrixes confirm that all associations between outcomes and the two measures of health expenditure are significant, presenting negative correlations below 50%. Deaths is equally associated with both spending measures (55%), while YLL has a slightly stronger link with Public Health Exp pc (-57.4%). Preventable Mortality shows its strongest link with Public Health Exp pc (-54.6%), while Treatable Mortality displays slightly stronger statistical ties Health Exp pc (59.9%). Public Health Exp pc presents slightly stronger relationships with all four outcomes than total Health Exp pc (Table 2). GDP pc forms the same associations with all four outcomes as Health Exp pc and Public Health Exp pc did, showing, too, a stronger bond with Treatable Mortality (-61.8%), and an equally weaker association with the number of Deaths from all causes and Years of Life Lost (-53.8%) (Table 2). Unemployment and Elderly Population are significantly correlated with all outcomes. Unemployment has a positive impact in all outcomes, with correlations varying from 18.4% for Preventable Mortality to 24.3% for Treatable Mortality. Elderly Population had a negative impact on all four measures of health, ranging from 9% for Preventable Mortality to 22.2% for YLL. Smoking Daily is positively and significantly associated with all four measures of health status, varying from a Pearson's r of 20.8% with regards to YLL and 41.1% relating Deaths from all causes. Low Educational Attainment revealed to produce non-significant correlations with all four health outcomes of interest. The weakest significant relationships were established between the share of Elderly Population and Preventable Mortality (-9%) and Elderly Population and Deaths (-12.2%). On the other hand, the strongest significant associations were held between of Treatable Mortality and Public Health Exp pc, and Treatable Mortality and GDP pc (both at -61.8%) (Table 2).

Table 4: Correlation Matrix – Bivariate associations between health outcomes and determinants

		Deaths per 100,000 pop	YLL per 100,000 pop	Preventable Mortaliy per 100,000 pop	Treatable Mortality per 100,000 pop
Health Exp pc (PPP, USD)	Pearson Correlation	-.553**	-.540**	-.522**	-.599**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00
	N	556.00	556.00	538.00	538.00
Public Health Exp pc (PPP, USD)	Pearson Correlation	-.554**	-.574**	-.546**	-.618**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00
	N	557.00	557.00	539.00	539.00
GDP pc (PPP, USD)	Pearson Correlation	-.538**	-.610**	-.538**	-.618**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00
	N	575.00	575.00	557.00	557.00
Unemployment (%)	Pearson Correlation	.199**	.188**	.184**	.243**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00
	N	540.00	540.00	522.00	522.00
Elderly Population (%)	Pearson Correlation	-.122**	-.222**	-.090*	-.212**
	Sig. (2-tailed)	0.00	0.00	0.03	0.00
	N	575.00	575.00	557.00	557.00
Low Educational Attainment (%)	Pearson Correlation	-0.01	0.14	-0.06	0.20
	Sig. (2-tailed)	0.96	0.43	0.76	0.28
	N	33.00	33.00	33.00	33.00
Smoking Daily (%)	Pearson Correlation	.411**	.208**	.331**	.278**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00
	N	299.00	299.00	293.00	293.00

Between health determinants

A second Person correlation analysis was constructed to observe bivariate relationships between health determinants of interest (Table 3). As expected, all three associations between Health Exp pc, Public Health Exp pc and GDP pc are positive and statistically significant, ranging from a correlation of 82.7% between GDP and Health Exp, to a very high coefficient of 95.4% between Health and Public Health Exp. Health Exp was also significantly and positively associated with Elderly Population (35.2%), but negatively with all the three remaining variables, with the strongest relationship being held with Smoking Daily (-43.8%). Public Health Exp pc and GDP pc presented the same behaviour, with quite similar relationships with Elderly Population (0.396 and 0.347, respectively) and Smoking Daily (-0.417 and -0.351, respectively). The only two remaining significant associations were positive and held between Unemployment and Elderly Population (13.7%) and Unemployment and Smoking Daily (21.8%). Low Educational Attainment had non-significant associations with Unemployment, Elderly Population and Smoking Daily. Smoking Daily and Elderly Population presented a non-significant link.

Table 5: Correlation Matrix – Bivariate associations between health determinants

		Public Health Exp pc (PPP, USD)	GDP pc (PPP, USD)	Unemployment (%)	Elderly Population (%)	Low Educational Attainment (%)	Smoking Daily (%)
Health Exp pc (PPP, USD)	Pearson Correlation	.954**	.827**	-.275**	.352**	-.410*	-.438**
	Sig. (2-tailed)	0.00	0.00	0.00	0.00	0.02	0.00
	N	589.00	589.00	564.00	589.00	33.00	307.00
Public Health Exp pc (PPP, USD)	Pearson Correlation		.851**	-.307**	.396**	-.411*	-.417**
	Sig. (2-tailed)		0.00	0.00	0.00	0.02	0.00
	N		590.00	565.00	590.00	33.00	308.00
GDP pc (PPP, USD)	Pearson Correlation			-.316**	.347**	-.359*	-.351**
	Sig. (2-tailed)			0.00	0.00	0.04	0.00
	N			569.00	608.00	33.00	311.00
Unemployment (%)	Pearson Correlation				.137**	0.32	.218**
	Sig. (2-tailed)				0.00	0.07	0.00
	N				569.00	33.00	301.00
Elderly Population (%)	Pearson Correlation					-0.32	0.11
	Sig. (2-tailed)					0.07	0.05
	N					33.00	311.00
Low Educational Attainment (%)	Pearson Correlation						0.24
	Sig. (2-tailed)						0.25
	N						25.00

Figures 4: Health outcomes per level of Health Expenditure and Public Health Expenditure, 2017

Figure 4.1

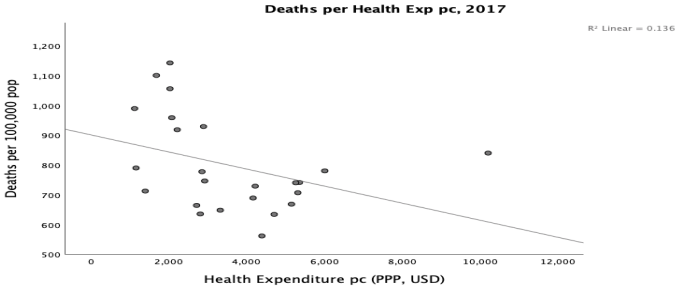


Figure 4.2

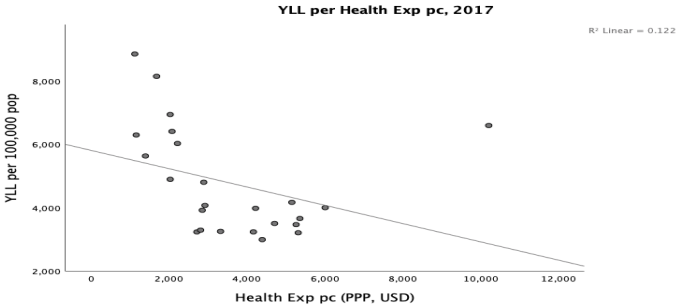


Figure 4.3

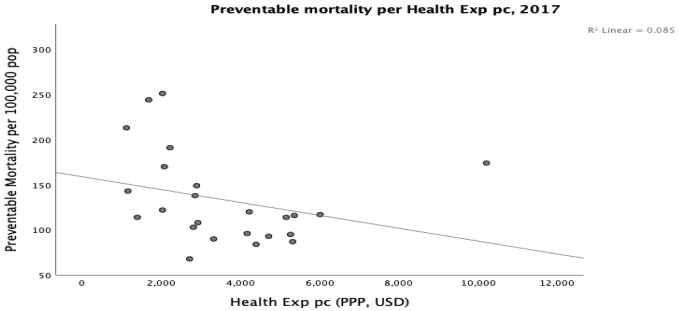


Figure 4.4

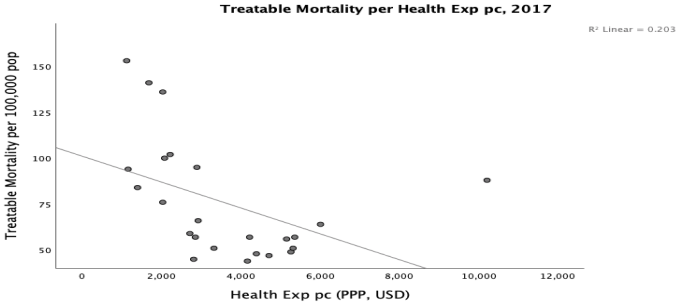


Figure 4.5

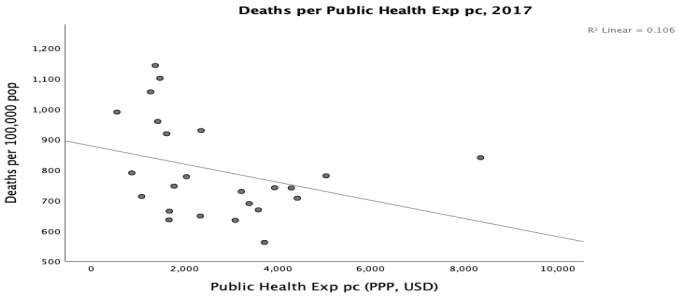


Figure 4.6

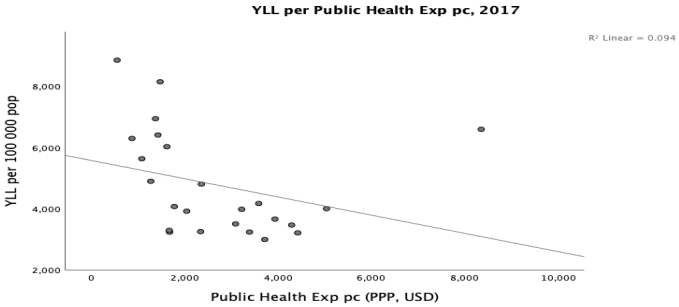


Figure 4.7

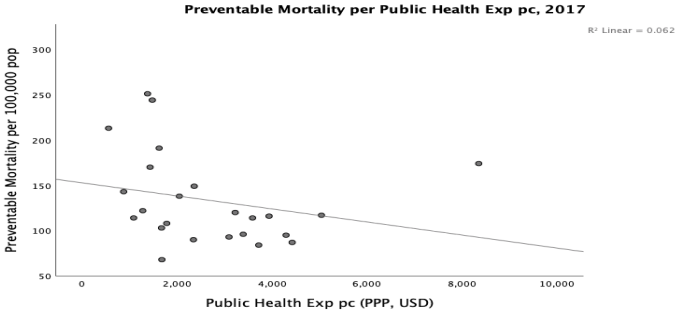
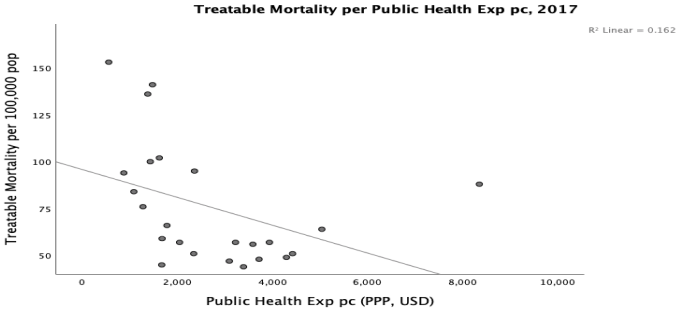


Figure 4.8



Figures 5: Evolution of health outcomes per level of health expenditure and public health spending, per country, 2002-2017

Figure 5.1

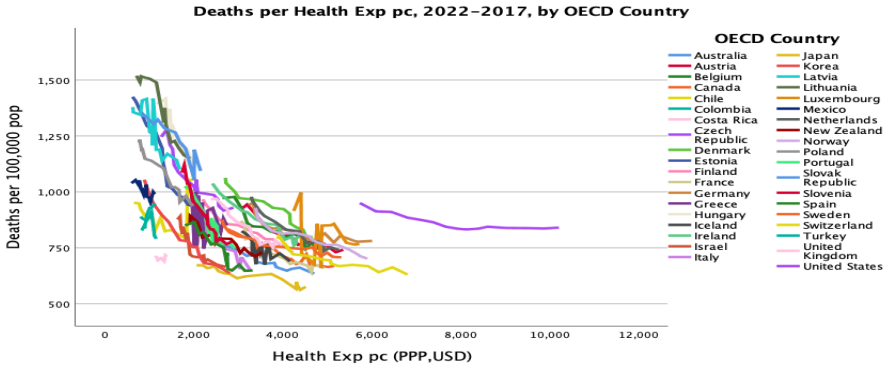


Figure 5.2

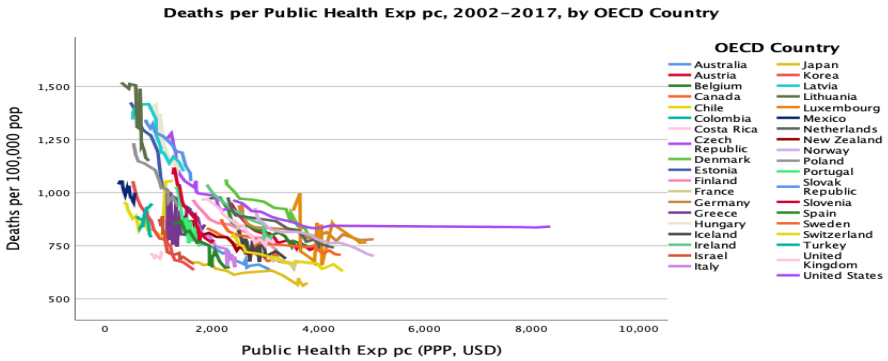


Figure 5.3

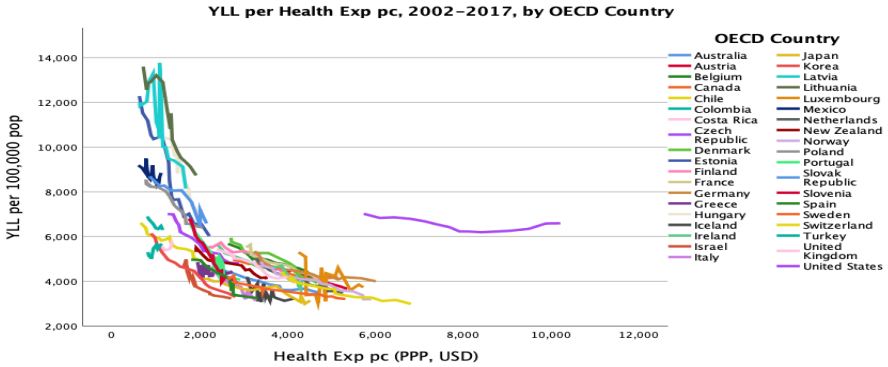


Figure 5.4

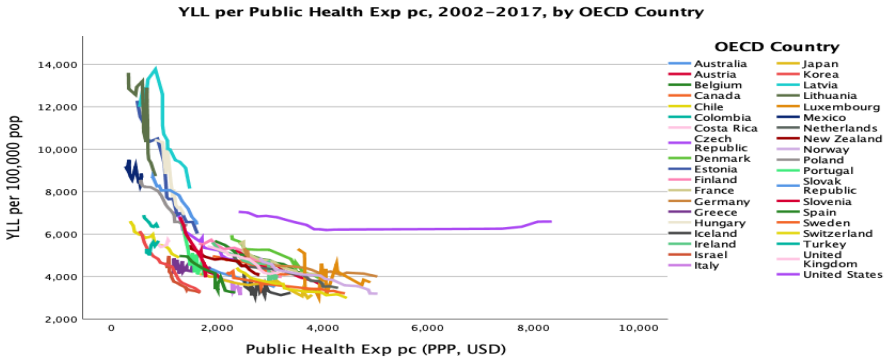


Figure 5.5

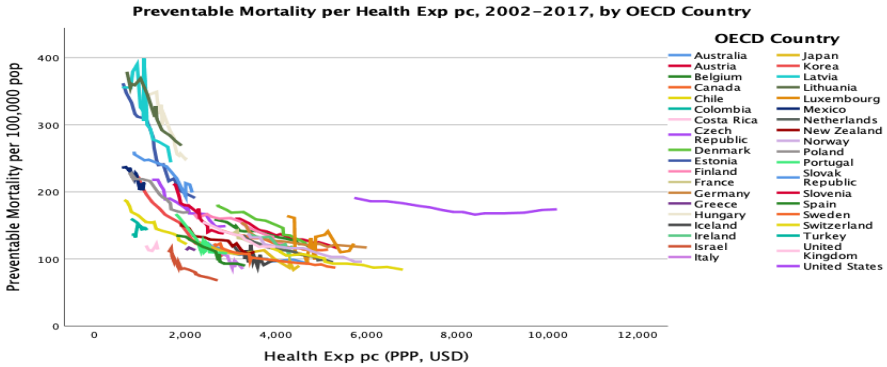


Figure 5.6

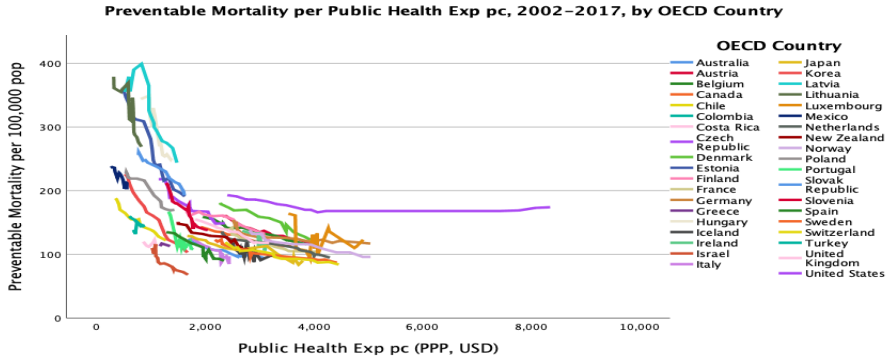


Figure 5.7

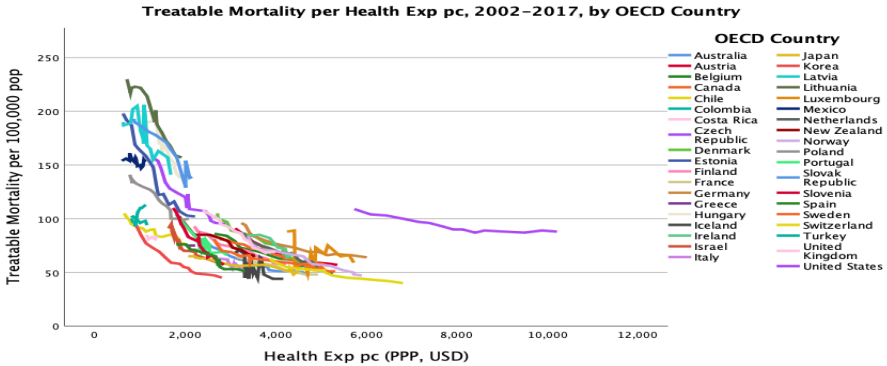
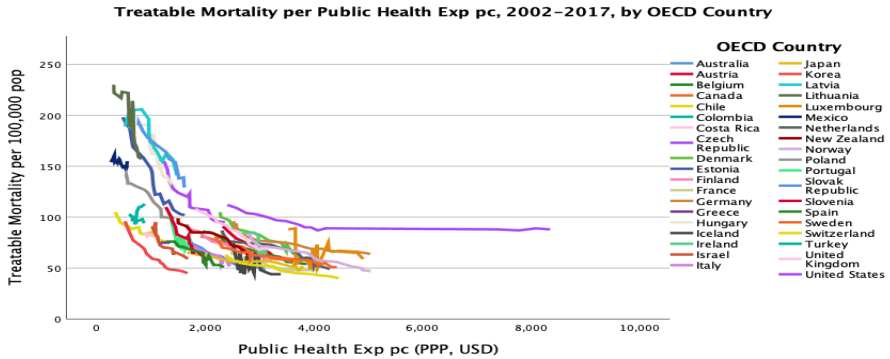


Figure 5.8



4.3 Multivariate analysis

Generalized linear mixed models were built to observe how health spending is linked to health outcomes.

Health Expenditure per capita

Health Expenditure per capita showed to be negatively and significantly associated with Deaths, YLL and Treatable Mortality, in the absence of GDP per capita as explanatory variable (Table 6, Models 1, 2, 5, 6, 9, 10, 13, and 14). An increase of 1,000 US dollars in total health spending per capita was linked to a decline of 2.9% in the number of Deaths (model 2), a similar reduction of YLL (Model 6), and a decrease of 4.6% in Treatable Mortality (model 14). In these three models (model 2, 6 and 14), the percentage of Elderly Population and the rate of those adults Smoking Daily were always significant associated with each outcome. Elderly population was linked to the improvement of outcomes, with a 1 percentage point increase in the percentage of those aged more than 65 years of age associated with a reduction of 1.3% of Deaths, 2.6% of YLL and 2.3% of Treatable Mortality. Smoking Daily had the opposite effect, contributing to worse outcomes, with a 1 percentage point increase in the prevalence of smoking among adults associated with an increase of 1.4% of Deaths, 1.8% of YLL and 2.8% of Treatable Mortality. Unemployment contributed in a statistically significant negative way for Deaths and Treatable Mortality (Model 2 and 14). A 1 percentage point increase in Unemployment was associated a 0.3% and 0.5% decrease in Deaths and Treatable Mortality respectively. In all models that simultaneously included GDP per capita as explanatory variable (Models 1, 5, 9, and 13), Health Expenditure was statistically non-significant, i.e., in all cases it became unrelated to all four health outcomes. Health Expenditure was also non-significantly related to Preventable Mortality when GDP per capita was not considered in the model (Model 10).

Public Health Expenditure per capita

Public Health Expenditure per capita showed to be positively and significantly associated with YLL and Preventable Mortality, when considered alongside GDP per capita as explanatory variable (Table 6, Models 3, 4, 7, 8, 11, 12, 15, and 16). An increase of 1,000 US dollars in total health spending from public sources per capita was associated to an increase of 2.4% in the number of YLL (Model 7), and a growth of 2.3% in Preventable

Mortality (11). In these two models (Models 7 and 11), GDP per capital, the percentage of Unemployment, the percentage of Elderly Population and the rate of adults Smoking Daily were always statistically significantly linked to the two health outcomes. An increase in GDP per capita of 1,000 US dollars was negatively linked to YLL (1%) and Preventable Mortality (0.9%). Unemployment contributed in a statistically significant negative way for YLL and Preventable Mortality. A 1 percentage point increase in Unemployment was associated a 0.6% and 0.5% decrease in YLL and Preventable Mortality respectively. Elderly population was also associated to the improvement of outcomes, with a 1 percentage point increase in the proportion of those aged above 65 related to a reduction of 3.3% of YLL and 3.9% of Preventable Mortality. Smoking Daily had the opposite effect contributing to worse outcomes, with a 1 percentage point increase in smoking rates associated with an increase of 0.6% of YLL and 0,9% of Preventable Mortality. In all models that excluded GDP per capita as explanatory variable (Models 4, 8, 12 and 16), Public Health Expenditure was found statistically non-significant. Health spending from public sources was also non-significantly linked to Deaths and Treatable Mortality when accounting for the effect of GDP (Models 3 and 15).

Table 6: Generalized Mixed Models for Deaths, YLL, Preventable Mortality and Treatable Mortality as functions of independent variables of health expenditure and covariates

	Deaths							
	Model 1		Model 2		Model 3		Model 4	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Intercept	7.141	0.000	6.765	0.000	7.161	0.000	6.738	0.000
Health Exp pc per 1000	-0.003	0.726	-0.029	0.000	--	--	--	--
Public Health Exp pc per 1000	--	--	--	--	0.009	0.134	-0.008	0.265
GDP pc per 1000	-0.007	0.000	--	--	-0.007	0.000	--	--
Unemployment	-0.006	0.000	-0.003	0.039	-0.005	0.000	-0.002	0.122
Elderly Population	-0.015	0.000	-0.013	0.001	-0.017	0.000	-0.019	0.000
Smoking Daily	0.006	0.000	0.014	0.000	0.006	0.000	0.016	0.000

	YLL							
	Model 5		Model 6		Model 7		Model 8	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Intercept	9.216	0.000	8.634	0.000	9.241	0.000	8.613	0.000
Health Exp pc per 1000	0.008	0.409	-0.029	0.006	--	--	--	--
Public Health Exp pc per 1000	--	--	--	--	0.024	0.001	0.002	0.821
GDP pc per 1000	-0.010	0.000	--	--	-0.010	0.000	--	--
Unemployment	-0.006	0.000	-0.003	0.182	-0.006	0.001	-0.001	0.468
Elderly Population	-0.029	0.000	-0.026	0.000	-0.033	0.000	-0.035	0.000
Smoking Daily	0.006	0.004	0.018	0.000	0.006	0.002	0.021	0.000

	Preventable Mortality							
	Model 9		Model 10		Model 11		Model 12	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Intercept	5.625	0.000	5.126	0.000	5.655	0.000	5.117	0.000
Health Exp pc per 1000	0.005	0.584	-0.020	0.055	--	--	--	--
Public Health Exp pc per 1000	--	--	--	--	0.023	0.002	0.008	0.358
GDP pc per 1000	-0.008	0.000	--	--	-0.009	0.000	--	--
Unemployment	-0.006	0.003	-0.004	0.091	-0.005	0.005	-0.003	0.159
Elderly Population	-0.035	0.000	-0.033	0.000	-0.039	0.000	-0.040	0.000
Smoking Daily	0.009	0.000	0.020	0.000	0.009	0.000	0.022	0.000

	Treatable Mortality							
	Model 13		Model 14		Model 15		Model 16	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Intercept	4.869	0.000	4.336	0.000	4.904	0.000	4.306	0.000
Health Exp pc per 1000	-0.017	0.127	-0.046	0.000	--	--	--	--
Public Health Exp pc per 1000	--	--	--	--	0.009	0.313	-0.009	0.348
GDP pc per 1000	-0.009	0.000	--	--	-0.010	0.000	--	--
Unemployment	-0.008	0.001	-0.005	0.028	-0.007	0.001	-0.005	0.056
Elderly Population	-0.024	0.000	-0.023	0.000	-0.031	0.000	-0.033	0.000
Smoking Daily	0.016	0.000	0.028	0.000	0.017	0.000	0.031	0.000

5. Discussion

The purpose of this study was to contribute to the measurement of the links between health outcomes and health expenditure, using data available from all OECD countries between 2002 and 2017. Outcomes included the standardized number of all-cause deaths, the number of years of life lost until the age of 75, and preventable and treatable deaths, all presented per 100,000 population. Health expenditure, both total and from public sources of funding, were measured at purchasing power parity, in US dollars, per capita. Covariates included the share of population above 65 years of age, the rate of unemployment, the share of adults smoking daily, along with gross domestic product also measured at purchasing power parity, in US dollars, per capita.

In short, during the period under analysis, all health outcomes improved, with slight setbacks during 2011, a period marked by an economic crisis. Health spending, both total and from public sources, exhibited increasing patterns. GDP grew steadily except in 2009, while unemployment increased during six out of the sixteen years analysed, with the most relevant growth occurring from in 2009. The rate of elderly population revealed a positive evolution while that of adults smoking daily moves in the opposite direction. Among countries, variations overtime existed in all measures of outcomes, with countries mostly maintaining their relative position to others, i.e., those with better outcomes at the beginning of the period were the same at the end of the period, and vice-versa. With regards to spending, minimum values doubled during the period, but those spending more in 2002 increased expenditure by over 130% until 2017. In bivariate analysis, expected high correlations were found between GDP and spending measures and between expenditure measures themselves. Graphical examination alerted to the outlying behaviour of the US with regards to bivariate links between spending, total and public, and outcomes. Finally, the multivariate investigation allowed the identification of two main results:

- Concerning total health spending, an absence of association was observed between total health spending and health outcomes when the effect of GDP is controlled for in the model. Significant and negative relationships were only measured when GDP is not adjusted for, between total spending and deaths from all causes, years of life lost and treatable mortality. Because GDP and total expenditure are highly correlated, it becomes impossible to separate in the coefficient the true effect of health spending from the effect of wealth. When adjusting for GDP, health spending becomes unrelated to health outcomes.

- Concerning public health spending, positive and significant relationships were observed between health spending from public sources and years of life lost and preventable mortality, after controlling for all covariates including GDP. Because a causal link cannot be established by this finding, they show the existence of a bidirectional link of an adverse nature between this spending variable and each of the two outcomes, once equal covariates are held constant. Public spending also showed to be unable to explain all-cause deaths and treatable mortality, when adjusting for the effect of wealth. However, even when not controlling for GDP, public health spending is not able to explain any of the outcomes, pointing out that wealth has a salient role in health results.

Because of goals, model and data set differences among studies, direct comparisons are rather difficult to establish. However, the expected association between total spending and health outcomes is well documented in contemporaneous literature. Associations have been established between several measures of total spending, both all-cause and disease-specific, including per capita and as a share of GDP, and mortality (152,154,157), infant mortality (164), life expectancy (147,159,165), years of life lost (145,147,152) and avoidable mortality (148,151,160). In general, links were statistically significant and negative, except for life expectancy, in which case the associations were positive. These relationships were also modelled in different ways with covariates varying slightly according to the region under analysis, but including lagged (148) and country-specific effects (164), environmental determinants, like sanitation (150,162,164,174) or pollution (145,146), material and social covariates, like GDP (145,147,150,158,174), unemployment (146,148–150,152,153,157–160), social status (145,159), the share of elderly population (148,149,157,158,160), education (148,151,158,159,164,174), health care resources (146,150,157–159,164) and social services (147,153,158,160), along with lifestyle determinants, like smoking (145,146,148,159), alcohol consumption (145,146,148,159) and nutritional habits (145,146,159). In general, covariates similar to those used in this study behaved in the expected direction.

Therefore, because results from this study show that health expenditure does not appear to be a good predictor of outcomes when the effect of wealth is considered, findings are not consistent with previous literature. This may occur for several reasons. First, this study uses data for the period between 2002 to 2017, in a total of 16 years, while previous research mostly considers either periods before the onset of the economic crisis (148,150,151,154,160,165) or a small number of years after crisis (153), not intertwining both in the extent that this study has done. Further research including periods before and

after crisis (not only the past economic crisis, but also the present public health one) would be of value. Second, health expenditure may not be able to explain results because other living, working and social conditions, along with other behavioural determinants have gained a more salient impact in health status that needs to be taken into account. In a region and at a time in which, in general, basic needs of food, shelter, education, access to health, safety, and participation in community life (175) are met, factors like labour conditions, social support, community networks, and individual risk-taking behaviours towards physical activity or nutrition, may account for a more significant portion of results than ever before or than in other regions. Research assessing the effect of additional covariates in the link between spending and outcomes, for the period before and after the economic crisis, is therefore needed. Also, research on the role of social health-related spending, as has been done extensively by previous authors focusing in the US, the UK or Canada, could be useful. Third, outcomes may be influenced by circumstances that were not addressed by health expenditure. Traffics accidents, pollution, underdiagnosed conditions, like mental disorders, or undertreated ones, like chronical diseases, especially in the aftermath of the economic and social crisis, for example, may have had an impact on outcomes that expenditure is not able to mirror. Research on the nature and components parts of health outcomes could shed light on the matter. Inside the opposite set of those circumstances not reflected upon outcomes but covered by expenditure we find the next possible explanations of the absent association between spending and health results. Fourth, the impact of technological and technical progress, in medical and pharmacologic care, leading to more expensive patterns of care, may have, in the last decades disproportionately increased its cost, thus dissociating the amounts spent from the results in health (119,120). In this situation, not only GDP could prove to be a more reliable aggregate predictor of outcomes, while disease-specific indicators revealed themselves more sensitive to the association. Research on the disease-specific evolution of patterns and cost of care due to technical and technological progress could shed precious light on the question. Fifth, also organization of the health systems may have behaved differently across locations. Total expenditure is an aggregate measure, that includes both public and private spending, covering three major designs in OECD, from national health systems, and social health insurance to private mandatory insurance (supported by state subsidies for those unable to pay). How expenditure is shared between private and public, organized or pooled buyers, and how different systems invest funds to generate good results may have given rise to the lack of association. The particular position of the US as an outlier in bivariate associations, with the highest spending on health among all OECD countries, both total and from public sources, could strongly affect the results.

Logically, additional research clarifying these aspects and the particular role of the US in the lack of association is warranted. Finally, from a micro-perspective, individual expectations may render public and private spenders unable to decline care that has a disproportionate cost when compared to its consequent benefits, i.e., care that is non-cost-effective. Research on how health spending decisions are taken, both at the individual and the organizational level with be helpful in this case.

Like in the case of total health spending, the association between expenditure from public sources of funding and outcomes is also well documented in contemporary research. Links have been acknowledged between several measures of public spending, including per capita, as a share of total spending and as a share of GDP, and mortality (150,153), infant mortality (149,164) child mortality (150,162,174), life expectancy (149) and years of life lost (145). Negative and statistically significant associations (149,150,164,174) were found with several outcomes, except for life expectancy, in which case the associations were also in the expected positive direction (149). Positive and significant associations were also founded between public spending and mortality (150) or years of life lost (145). Because almost always in conjunction with total spending, relationships with public spending were modelled, in general, with the contributions of the same covariates as indicated for total health spending, including sanitation (150,164,174), pollution (145,146), GDP (145,149,150,158,164), unemployment (146,149,150,157,158,160), social status (157), the share of elderly population (149,150,157,158,160), education (145,164,174), health care resources (146,150,157,158,164) and social services (147,158,160), along with smoking (145,146), alcohol consumption (145,146) and nutritional habits (145,146,150).

This study shows that public funding of health expenditure is a good predictor of two outcomes, years of life lost and preventable mortality, but fails to explain all-cause and treatable deaths, when wealth is considered and all other covariates are controlled for. The first tow finding shows a positive association between public spending and outcomes, being consistent with a small portion of previous literature. The following two findings fail to confirm earlier research. This may occur for several reasons. First, because total health expenditure incorporates in itself public spending, the reasons mentioned above apply as possible explanations for the findings relating to public spending, namely the time period under consideration, other health determinants beyond spending, circumstances that were not covered by spending but have a reflection upon outcomes, and, in the opposite direction, circumstances that are not contemplated within outcomes but have a reflection upon public expenditure, including technological progress and more expensive standards of care, organization of the system and individuals'

expectations. With regards to this last aspect, it is important to bear in mind that public spending is the object of political decisions, which are shaped not only by budgetary constraints and pressures but also by political ideologies and expectations of individuals. Ideologies and expectations, propelled by traditional and innovative media and by the human inability to project its health status into the future, shape how political decision-makers allocate funds among the different areas of state intervention. OECD countries may have reached a level of development in which expectations do drive expenditure in a significant extent, but not outcomes. Research on determinants of political decisions would enlighten the discussion. With regards to the positive link between public spending and all-cause and treatable deaths, two further aspects could help explain the unfavourable association with public spending. On one hand, how contemporary allocation of funds among functions (including preventive, curative, rehabilitative and long-term care) is done, and the extent of acknowledgment of the impact of social services upon health do matter to the evolution of not only public spending but also health results. How effectively, efficiently, and responsively public health expenditure is used affects reduction of the number of deaths that could be avoided if preventive care was rendered before the onset of disease and of the number of those dying ahead of their time. Research on effectiveness, efficiency, and responsiveness to current epidemiological profiles, along with allocation strategies across OECD countries could prove useful. Finally, because there is a link between poverty, lower socio-economic position or older age and worse health, and public spending is generally rooted in the need to ensure care for those less able to pay and possibly lower capacity to benefit, spending from public sources could be focusing, not in preventing deaths, but on complex and costly interventions without a sizable effect upon outcomes. Research on the extent to which public spending is focusing on such targets could enlighten the discussion on positive association between public spending and specific outcomes.

Covariates used in this study deserve further discussion. Three measures, GDP, elderly population and the rate of adults smoking daily, showed coefficients in the expected direction that were in all situations statistically significant. GDP was negatively associated with all four outcomes of the study, with previous literature confirming the same favourable pattern with regards to infant mortality (143,149,159,162–164), under-five mortality (162,164,174), maternal mortality (174), life expectancy (149,159) and premature mortality (145). The share of adults smoking daily showed to always have a detrimental impact in all four outcomes addressed, with previous research confirming the same effects on premature mortality (145), infant mortality and life expectancy (159). The rate of those above 65 years of age was negatively associated with all four outcomes

in this study, showing a beneficial effect on health results. Previous literature also exhibited a similar impact on avoidable mortality (160).

The same did not happen with the rate of unemployment. Significance revealed itself dependant on the inclusion of GDP in the model. Once controlling for wealth, the effect of unemployment was in all cases negative, meaning that an increase in the rate of unemployment was linked to a beneficial decrease in each of the four health outcomes. Such behaviour is consistent with research on the association of health spending and outcomes (149) and with previous research on the effects of unemployment in health (31–34). This also may happen for a number of reasons. First, as explained earlier, this study considers a period of economic crisis, in which rates of unemployment raised significantly. Because some conditions developed, underdiagnosed or undertreated during the crisis, might have a lagged effect on health results, like mental health, neurological and oncological issues, considering a longer period might produce a different effect in the association between unemployment and outcomes. Second, because reductions in insurance coverage due to loss of job have already showed little evidence of reducing health care utilization (33), private out-of-pocket spenders along with organized public and private spenders may respond to health needs by modifying their patterns of consumption and by accessing to savings and monetary reserves. This may be able to prevent the emergence of worse health outcomes when unemployment raises. A different set of countries and a wider period of analysis could render such behavior and its effectiveness difficult to maintain across time. Third, in OECD countries, those unemployed tend to have access to social support, being able to maintain some financial safety and keeping basic needs satisfied, without endangering their and their families' health status. Finally, job loss and the associated reduction in displacements, appear to have contributed to reducing traffic (33), work-related and other (31) injuries and deaths, thus positively affecting the link between unemployment and outcomes. With regards to the effect of unemployment in the link between spending and health, research on lagged effects of unemployment, covering longer periods, both after and during crisis, on how patterns of consumption change and on how they can be sustained across time once job is lost could prove useful.

6. Limitations

First, Dahlgren and Whitehead (1991) systematized determinants of health in five levels of influence, including structural environment, material and social conditions in which people live and work, social and community networks that link them to others, individual lifestyles and constitutional factors. While the last embodies a set of features rather constant and little prone to change by health policy, all other groups, being vertically and synergistically integrated, successively influence and interact with each other across sectors, locations, communities and individuals. This study has examined a small sample of a wide variety of determinants. With regards to the structural environment, only GDP and the rate of elderly population were taken into account. Though GDP plays a central role in analysing the effect of health expenditure upon outcomes, and the rate of elderly reflect a pressing contemporary concern, factors like climate, pollution and the natural environment may contribute decisively to health outcomes. Regarding material and social conditions, though the rate of unemployment was taken into account, education, occupation, social-economic status, working conditions and housing were not taking into consideration in the study. Smoking daily was the only lifestyle trait considered, but nutrition, physical inactivity, consumption of drugs and alcohol have all proved to be linked to health. Social and community networks along with constitutional factors, though affecting health outcomes, were totally absent from the study. Taking into account additional determinants, along with their interactions, is crucial to understand not only their role in health results, but also how they affect the association between spending

Second, outcomes such as the one used are reliable measures of population health. However, aggregate outcomes do not account for other aspects that are relevant to patients' health, like morbidity, quality of life or experience of care. Also, disaggregation by country, age and gender could have enlightened the study.

Third, the absence of lagged effects in the analysis of health spending on health outcomes is also a limitation of this study. Such model specification has prevented the analysis from capturing the impact of lagged effects of spending across time.

Fourth and finally, with regards to data quality, limitations may also exist in definitions across countries, methods of data collection, measurement of indicators per country, along reporting. As OECD's online platform on statistics points in each country's notes on sources and comparability (142), accounting systems that record total and public spending on health are seldom similar across countries, and thus different countries may measure slightly different concepts

7. Conclusion

Findings of this study using recent data from OECD countries suggest that the association between health expenditure, total or from public sources, and population health outcomes remains puzzling, raising questions on which factors within health spending do not have a sizeable effect on outcomes, which factors affecting outcomes fall outside the scope of health expenditure, and at the end of the day which factors should be measured when researching the association.

This study indicates that the lack of expected associations between health spending and health outcomes may be due, first, to the use of recent data. Also, other health determinants not accounted for in this study may have developed across time more salient influences on health results, like the extent of pollution, working conditions, community networks, social support and individual risk-taking behaviours towards health. Factors not covered by expenditure but reflected upon outcomes may too have affected the link, like increased traffic accidents, underdiagnosed and undertreated conditions. On the other hand, further elements may affect expenditure without a sizable effect upon health results, like technological and technical progress and its reflection on more expensive patterns of care, the organization of care, and expectations of individuals and spenders. In the case of public spending, the lack of responsiveness to epidemiological profiles and a matching allocation of funds across functions of care, along with a focus on complex and costly interventions for those in lower socio-economic position or poverty may have had an important effect upon spending but no significant impact in outcomes.

Health is the multidimensional product of complex layers of factors. As conditions in which people live, work and bond to each other, behaviours and the environment evolve, traditional sets of health determinants may no longer suffice when addressing the association with outcomes. More than considerations about the effectiveness of expenditure, the absence of straight-forward favourable associations could indicate that, today, spending is required in a way that differs from previous periods of analysis.

In short, caution should be taken when judging the association of health expenditure, total or from public sources, and health outcomes in OECD countries, as several additional factors should be measured and further researched.

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Annex 1: Univariate descriptive statistics

1.1 Health Outcomes and Health Expenditure

Year		Health Outcomes							Health Expenditure					
		Deaths per 100,000 pop	Growth rate	YLL per 100,000 pop	Growth rate	Preventable Mort. per 100,000 pop	Growth rate	Treatable Mort. per 100,000 pop	Growth rate	Health Exp pc (PPP, USD)	Growth rate	Public Health Exp pc (PPP, USD)	Growth rate
2002	N	37		37		34		34		35		36	
	Mean	1,007.73		6,545.42		190.65		112.47		2,045.30		1,548.50	
	Std. Deviation	198.59		2,435.15		74.54		43.66	38.82%	1,041.47		836.36	
	Median	966.70		5,608.20		162.00		96.50		2,065.13		1,660.58	
	Minimum	671.70		4,112.80		116.00		63.00		519.98		256.35	
	Maximum	1,519.60		13,600.90		379.00		230.00		4,248.81		3,528.17	
2003	N	37		37		35		35		36		36	
	Mean	1,006.70	-0.10%	6,351.75	-2.96%	185.00	-2.96%	108.94	-3.14%	2,221.04	8.59%	1,603.89	3.58%
	Std. Deviation	200.30		2,329.14		72.83		42.95		1,198.88		850.67	
	Median	963.40		5,475.70		160.00		94.00		2,236.82		1,721.23	
	Minimum	671.50		3,540.70		110.00		61.00		509.68		285.80	
	Maximum	1,516.80		12,850.40		361.00		222.00		5,735.51		3,655.93	
2004	N	36		36		34		34		36		36	
	Mean	966.29	-4.01%	6,185.59	-2.62%	179.03	-3.23%	104.50	-4.08%	2,365.60	6.51%	1,704.68	6.28%
	Std. Deviation	200.67		2,330.83		72.62		43.82		1,262.38		900.72	
	Median	911.95		5,171.60		146.50		88.50		2,378.50		1,859.83	
	Minimum	658.90		3,886.10		104.00		57.00		558.57		333.57	
	Maximum	1,490.60		12,569.50		355.00		217.00		6,094.19		3,979.53	
2005	N	35		35		33		33		36		36	
	Mean	958.99	-0.76%	6,131.63	-0.87%	177.48	-0.86%	103.00	-1.44%	2,447.69	3.47%	1,765.00	3.54%
	Std. Deviation	209.04		2,477.82		74.30		44.91		1,294.18		920.03	
	Median	898.20		5,111.30		149.00		86.00		2,487.64		1,950.24	
	Minimum	666.20		3,516.10		101.00		57.00		588.13		325.90	
	Maximum	1,512.10		12,923.20		379.00		223.00		6,443.26		4,060.93	
2006	N	36		36		34		34		36		36	
	Mean	928.14	-3.22%	5,958.01	-2.83%	172.21	-2.97%	99.76	-3.14%	2,588.23	5.74%	1,880.48	6.54%
	Std. Deviation	206.90		2,474.54		75.34		44.52		1,348.01		975.82	
	Median	862.15		4,967.80		141.50		83.00		2,610.00		2,050.79	
	Minimum	644.60		3,872.50		97.00		55.00		677.66		351.93	
	Maximum	1,506.00		13,292.70		390.00		222.00		6,806.91		4,263.51	
2007	N	37		37		36		36		36		36	
	Mean	913.71	-1.55%	5,850.03	-1.81%	166.11	-3.54%	95.53	-4.25%	2,741.87	5.94%	1,994.28	6.05%
	Std. Deviation	203.21		2,487.99		73.39		42.54		1,393.84		1,012.08	
	Median	850.90		4,843.60		136.50		81.00		2,691.66		2,138.16	
	Minimum	635.60		3,609.30		94.00		53.00		733.09		381.21	
	Maximum	1,489.00		13,762.60		399.00		214.00		7,157.34		4,280.08	
2008	N	37		37		36		36		36		36	
	Mean	889.10	-2.69%	5,615.61	-4.01%	160.22	-3.55%	92.67	-3.00%	2,915.67	6.34%	2,140.69	7.34%
	Std. Deviation	185.16		2,248.47		68.31		40.37		1,449.06		1,073.10	
	Median	828.90		4,788.90		133.50		77.00		2,881.11		2,282.92	
	Minimum	633.50		3,313.50		88.00		52.00		807.05		413.17	
	Maximum	1,375.00		12,572.60		365.00		201.00		7,395.89		4,742.93	
2009	N	38		38		37		37		36		36	
	Mean	866.27	-2.57%	5,464.32	-2.69%	155.46	-2.97%	89.59	-3.32%	3,010.83	3.26%	2,229.94	4.17%
	Std. Deviation	174.52		2,010.59		61.78		38.44		1,499.94		1,111.55	
	Median	821.65		4,734.55		133.00		75.00		2,962.94		2,381.73	
	Minimum	613.40		3,413.70		85.00		52.00		817.02		426.14	
	Maximum	1,310.10		11,108.40		326.00		190.00		7,669.63		4,905.12	
2010	N	38		38		37		37		36		36	
	Mean	854.79	-1.33%	5,294.95	-3.10%	150.92	-2.92%	86.73	-3.20%	3,093.63	2.75%	2,287.02	2.56%
	Std. Deviation	171.83		1,926.58		60.13		37.19		1,523.97		1,119.31	
	Median	800.85		4,581.85		128.00		73.00		3,136.32		2,469.56	
	Minimum	622.40		3,381.90		86.00		48.00		843.27		449.07	
	Maximum	1,302.30		10,706.10		320.00		188.00		7,922.20		4,778.82	
2011	N	37		37		36		36		38		38	
	Mean	822.88	-3.73%	5,098.49	-3.71%	145.00	-3.92%	81.69	-5.81%	3,061.48	-1.04%	2,257.99	-1.27%
	Std. Deviation	149.48		1,828.26		56.60		34.63		1,587.87		1,156.10	
	Median	786.80		4,420.50		123.00		70.50		3,115.28		2,459.72	
	Minimum	632.80		3,110.20		84.00		45.00		803.02		481.59	
	Maximum	1,220.40		10,405.80		306.00		180.00		8,131.47		4,191.76	
2012	N	38		38		37		37		38		38	
	Mean	827.87	0.61%	4,999.62	-1.94%	143.00	-1.38%	81.35	-0.42%	3,158.51	3.17%	2,319.79	2.74%
	Std. Deviation	156.70		1,799.24		56.55		35.17		1,638.32		1,197.92	
	Median	786.25		4,308.55		120.00		69.00		3,155.82		2,466.80	
	Minimum	610.60		3,080.20		80.00		44.00		850.27		516.73	
	Maximum	1,227.50		10,015.70		300.00		173.00		8,404.94		4,415.39	
2013	N	38		38		37		37		38		38	
	Mean	814.60	-1.60%	4,896.92	-2.05%	139.73	-2.29%	79.95	-1.73%	3,279.79	3.84%	2,407.66	3.79%
	Std. Deviation	154.80		1,733.26		53.70		34.36		1,690.08		1,244.91	
	Median	771.00		4,198.55		123.00		66.00		3,215.59		2,482.97	
	Minimum	598.00		3,268.80		78.00		44.00		938.67		538.89	
	Maximum	1,195.80		9,989.10		294.00		168.00		8,610.60		4,664.25	
2014	N	38		38		38		38		38		38	
	Mean	796.01	-2.28%	4,781.72	-2.35%	135.50	-3.03%	77.16	-3.49%	3,356.85	2.35%	2,539.08	5.46%
	Std. Deviation	149.93		1,712.48		51.73		33.07		1,748.39		1,478.05	
	Median	749.70		4,124.80		118.00		64.00		3,268.50		2,501.49	
	Minimum	583.20		3,118.30		76.00		43.00		998.58		515.38	
	Maximum	1,163.30		9,481.60		278.00		159.00		9,034.17		7,388.87	
2015	N	36		36		36		36		38		38	
	Mean	800.98	0.63%	4,711.11	-1.48%	132.86	-1.95%	76.39	-1.00%	3,457.87	3.01%	2,614.40	2.97%
	Std. Deviation	149.00		1,696.09		51.10		32.73		1,792.48		1,515.13	
	Median	769.60		4,130.90		117.50		65.00		3,305.41		2,532.23	
	Minimum	575.70		3,021.60		75.00		42.00		1,040.37		554.68	
	Maximum	1,170.10		9,405.40		275.00		163.00		9,498.29		7,777.65	
2016	N	33		33		33		33		38		38	
	Mean	781.03	-2.49%	4,605.10	-2.25%	128.48	-3.29%	73.33	-4.00%	3,623.14	4.78%	2,748.91	5.14%
	Std. Deviation	146.00		1,628.05		46.42		31.02		1,853.27		1,569.68	
	Median	746.20		4,089.20		116.00		60.00		3,518.31		2,685.87	
	Minimum	566.50		2,990.30		72.00		40.00		1,084.54		565.52	
	Maximum	1,142.10		9,121.50		267.00		157.00		9,880.16		8,079.66	
2017	N	24		24		24		24		38		38	
	Mean	798.55	2.24%	4,774.10	3.67%	133.33	3.77%	75.83	3.41%	3,766.56	3.96%	2,841.68	3.37%
	Std. Deviation	158.95		1,687.40		50.01		31.97		1,910.82		1,622.06	
	Median	744.00		4,036.45		116.50		61.50		3,609.81		2,754.48	
	Minimum	562.00		2,994.40		68.00		44.00		1,118.97		555.72	
	Maximum	1,142.80		8,849.30		251.00		153.00		10,212.75	3.52%	8,349.31	

1.2 Covariates

Year		Covariates									
		GDP pc (PPP, USD)	Growth rate	Unemployment (%)	Growth rate	Elderly Population (%)	Growth rate	Low Educational Attainment (%)	Growth rate	Smoking Daily (%)	Growth rate
2002	N	38		30		38				19	
	Mean	24,305.04		7.65		13.39				24.12	
	Std. Deviation	11,114.95		4.16		3.67				3.91	16.21%
	Median	26,649.07		6.34		14.50				25.00	
	Minimum	6,594.67		2.76		5.20				14.60	
	Maximum	58,709.02		19.93		18.70				29.00	
2003	N	38		33		38				20	
	Mean	24,967.09	2.72%	7.49	-2.02%	13.52	0.96%			25.22	4.54%
	Std. Deviation	11,134.22		3.80		3.72				4.44	
	Median	26,598.42		6.26		14.80				26.00	
	Minimum	7,065.08		3.34		5.30				17.20	
	Maximum	59,955.40		19.62		19.10				33.00	
2004	N	38		33		38				19	
	Mean	26,482.96	6.07%	7.57	1.08%	13.66	1.05%			24.37	-3.34%
	Std. Deviation	11,754.76		3.74		3.76				5.29	
	Median	27,628.48		6.53		14.80				25.00	
	Minimum	7,591.34		2.99		5.40				15.90	
	Maximum	63,993.31		18.98		19.50				38.60	
2005	N	38		34		38				18	
	Mean	27,815.47	5.03%	7.29	-3.70%	13.83	1.29%			22.15	-9.12%
	Std. Deviation	12,345.20		3.30		3.83				3.32	
	Median	28,817.02		7.33		14.85				23.10	
	Minimum	8,246.03		2.55		5.60				15.70	
	Maximum	68,140.65		17.75		20.20				26.00	
2006	N	38		35		38				22	
	Mean	30,297.59	8.92%	6.59	-9.58%	14.01	1.24%			23.09	4.25%
	Std. Deviation	13,593.99		2.59		3.91				5.83	
	Median	31,507.69		6.33		14.85				23.10	
	Minimum	8,968.12		2.83		5.70				13.00	
	Maximum	77,903.93		13.85		20.80				40.00	
2007	N	38		36		38				19	
	Mean	32,253.56	6.46%	6.01	-8.81%	14.17	1.16%			20.57	-10.90%
	Std. Deviation	14,270.86		2.29		3.98				3.12	
	Median	33,192.53		5.69		14.95				21.00	
	Minimum	9,729.02		2.24		5.80				13.80	
	Maximum	83,858.24		11.22		21.50				24.10	
2008	N	38		36		38				23	
	Mean	33,554.73	4.03%	6.11	1.61%	14.32	1.10%			21.81	6.02%
	Std. Deviation	14,743.11		2.20		4.01				5.76	
	Median	34,123.08		6.12		15.10				21.00	
	Minimum	10,139.64		2.55		5.90				10.80	
	Maximum	86,591.99		11.28		22.10				39.70	
2009	N	38		36		38				22	
	Mean	32,456.21	-3.27%	8.59	40.69%	14.50	1.23%			21.19	-2.85%
	Std. Deviation	13,978.02		3.54		4.07				5.46	
	Median	32,794.89		8.04		15.45				21.45	
	Minimum	10,301.17		3.10		6.00				7.60	
	Maximum	82,206.35		17.86		22.70				31.90	
2010	N	38		37		38				20	
	Mean	33,578.82	3.46%	9.10	5.91%	14.72	1.51%			19.49	-8.03%
	Std. Deviation	14,302.41		4.30		4.09				3.72	
	Median	33,308.97		8.15		15.75				19.25	
	Minimum	10,741.54		3.52		6.10				13.60	
	Maximum	85,514.87		19.86		23.00				26.20	
2011	N	38		37		38				15	
	Mean	35,225.29	4.90%	8.75	-3.83%	14.91	1.32%			18.14	-6.93%
	Std. Deviation	15,058.36		4.29		4.10				4.02	
	Median	34,221.37		7.77		16.00				17.80	
	Minimum	11,553.67		3.21		6.20				10.30	
	Maximum	91,814.04		21.39		23.30				23.90	
2012	N	38		37		38				20	
	Mean	36,011.38	2.23%	9.04	3.22%	15.23	2.14%			18.47	1.79%
	Std. Deviation	15,159.07		5.01		4.16				4.13	
	Median	34,334.56		7.68		16.45				17.70	
	Minimum	12,165.94		3.12		6.40				11.80	
	Maximum	91,526.72		24.79		24.10				26.00	
2013	N	38		37		38				20	
	Mean	37,530.42	4.22%	9.04	0.05%	15.55	2.09%			16.75	-9.29%
	Std. Deviation	15,643.60		5.28		4.22				3.20	
	Median	35,979.72		7.53		16.95				16.20	
	Minimum	12,841.28		3.10		6.50				10.70	
	Maximum	95,246.11		27.47		25.10				22.20	
2014	N	38		37		38		33		28	
	Mean	38,623.04	2.91%	8.57	-5.25%	15.87	2.06%	23.65		19.49	16.33%
	Std. Deviation	16,127.17		4.92		4.32		15.46		4.50	
	Median	36,565.89		7.36		17.35		18.45		19.65	
	Minimum	13,535.66		3.48		6.60		6.81		11.90	
	Maximum	100,933.60		26.49		26.00		66.30		27.30	
2015	N	38		37		38				17	
	Mean	39,863.19	3.21%	8.00	-6.67%	16.21	2.14%			15.14	-22.33%
	Std. Deviation	16,715.48		4.48		4.36				3.56	
	Median	36,997.31		6.82		17.75				15.00	
	Minimum	13,928.05		3.38		6.80				7.60	
	Maximum	102,817.29		24.90		26.60				19.80	
2016	N	38		37		38				20	
	Mean	41,055.72	2.99%	7.46	-6.73%	16.50	1.77%			16.76	10.73%
	Std. Deviation	16,876.92		4.15		4.41				4.52	
	Median	38,914.45		6.29		18.00				17.05	
	Minimum	14,276.06		2.97		6.90				10.20	
	Maximum	104,702.35		23.54		27.30				26.50	
2017	N	38		37		38				9	
	Mean	43,238.84	5.32%	6.73	-9.76%	16.79	1.80%			14.30	-14.68%
	Std. Deviation	17,466.41		3.80		4.44				4.06	
	Median	40,550.92		5.74		18.20				16.00	
	Minimum	14,607.03		2.74		7.10				7.60	
	Maximum	107,525.20		21.49		27.70				18.80	
Total	N	608		569		608		33		311	
	Mean	33,578.71	3.95%	7.76	-0.25%	14.82	1.52%	23.65		20.34	-2.92%
	Std. Deviation	15,386.41		4.06		4.16		15.46		5.30	
	Median	32,251.72		6.98		15.55		18.45		20.40	
	Minimum	6,594.67		2.24		5.20		6.81		7.60	
	Maximum	107,525.20		27.47		27.70		66.30		40.00	