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Health Status Determinants in the OECD Countries. A Panel Data Approach with Endogenous Regressors.

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Abstract

The purpose of this study is to analyse the determinants of life expectancy as proxy for health status of the OECD countries' population. A production function of health is used to explain life expectancy at birth for total and ageing population and according to gender. Socio-economic factors, health resources and lifestyles are defined as the main determinants of heath status. The estimation approach assumes that income and education are endogenous and a panel data approach is used to control for this problem. Our evidence shows that income, education and health resources (through consultations) are important factors affecting positively life expectancy and risky lifestyles (tobacco and alcohol consumption) are harmful to health. However there are differences between males and females. Income and lifestyles are the major determinants affecting men's health while for women education and the effective use of health services (through consultations) explain mostly life expectancy both at birth and late age.

JEL code: H51; I12; I18; C23

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1. Introduction

Health status of population is one of the major concerns of policymakers among the OECD countries. This concern is well reflected by statistics available on the latest *OECD Health Data 2009* report, which shows that, on average, health spending was in 2007 8.9% of the Gross Domestic Product (GDP). It is important to note, however, the large differences between countries: the USA is the country with the higher spending level – almost twice higher than the OECD average (16% GDP). However, as OECD (2009a) explains, it is also important to note that expensive health care is not necessary the best care.

In spite of the containing efforts in the health care spending of OECD countries, there are several factors that are likely to drive health spending higher in the coming future. As people tend to live longer, there are new challenges to deal with. Recent OECD projections suggest that health care spending will have a stronger pressure on public finances (Oxley, 2009). On the other hand, the nature of health problems has changed and it is increasingly related to chronic diseases, like diabetes or obesity, which affect growing rates of child and adult population but also the elderly.

There is a consensus that these challenges highlight the importance of primary prevention to reduce the rising incidence of diseases. Education, directly linked with health literacy[1], is seen as one driving force of health spending efficiency. Indeed, higher levels of education contribute to the development of cognitive and psycho-social competencies that play a critical role on explaining individuals' lifestyle choices. As Phelan and Link (2003) note, policymakers should look to the effects of education on poverty (or other social factors that affect health) as a means to improve public health.

Efforts to assess people's health status are strongly limited by availability and quality of data. The lack of data does not allow international comparisons and constitutes a severe restriction for empirical research. This is the main reason why the most common used

[1] According to WHO (1998), health literacy can be defined as "…the cognitive and social skills that determine the motivation and ability of individuals to gain access to, understand, and use information in ways that promote and maintain good health. Health literacy means more than being able to read pamphlets and successfully make appointments. By improving people's access to health information and their capacity to use it effectively, health literacy is critical to empowerment."

measures of population health status are life expectancy at birth[2] or at different ages, and mortality rates. Nevertheless, some authors (Or, 2000) also use an alternative indicator of premature mortality - "potential years of life lost" – that is available for OECD countries. However, as Joumard *et al*. (2008) note, this indicator doesn't consider survival after 70 years old in the OECD Health Data, which limits its application, since a large amount of health resources in rich countries are concentrated at the elderly population.

Wilkie and Young (2009) also note that the use of raw mortality and longevity indicators may underestimate health outcomes, mainly because health spending in developed countries (where significant gains in reducing mortality have already been made) is increasingly focusing on improving the quality of life.

Some other important and even more interesting measures of health outcomes would be the use of indicators that would express also more qualitative aspects of the health care system, such as cancer survival rates. However, once more the lack of data does not allow international comparisons.

In spite of some disadvantages of mortality and longevity indicators, mainly the fact that they underestimate qualitative information, Joumard *et al*. (2008) conclude that these remain the best available proxies of the health status.

Contrasting with less developed countries, where increased longevity is explained chiefly by a reduction in infant mortality rate, in developed countries the raise in life expectancy is mainly due to reductions in the mortality rates of the middle-aged and elderly. This trend is, partly, the result of technological and medicine improvements, medical prevention and treatments. Nevertheless, it is important to note that developed countries will have greater difficulties in obtaining a further increase in life expectancy. The effort will be concentrated in offering better quality of life through new treatments and better health care.

Increased longevity has important consequences both on individual behaviour (and decisions) and on aggregate level. As it is widely accepted a raise in life expectancy

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[2] Life expectancy can be considered as the health capital of one person and it is defined as the number of years a person is expected to live at birth or at various ages (for instance at 65 years of age).

makes investment in education more likely, because individuals expect to have the return of this investment for a longer period of time. On the other hand, as life expectancy at 65 years old tend to increase, people have to think in retirement planning for a longer period and so it influences expenditure/saving decisions over the life cycle. Along with the decrease in fertility rates, that also characterizes OECD countries, the ageing of rich countries poses severe problems of sustaining the social security systems. Finally, it is also important to mention that, as people get older and live more years, it is more likely the prevalence of certain diseases that imply the need for medical treatments and an increase on health care spending. This is a result known as the effect of general biological deterioration[3].

Since our study covers the OECD countries, in this paper we will concentrate exclusively on the longevity determinants. Our main aim is to contribute to disentangle and to better explain the effects (and magnitude) of income, education and lifestyles on life expectancy at birth (for total population, for males and females) and at 65 years old (for males and females) and whether the impact of these factors is different at various ages or gender. A panel data approach is used to estimate the health status equations controlling for the endogeneity of some of the determinants of health.

The paper is organized as follows. Section 2 explains the determinants of health status reviewing some of the existing literature. In sections 3 we explain the model, methodology and the data used in the empirical analysis. The results obtained from the estimation approach are presented and discussed in section 4. The last section summarizes the main findings suggesting some policy implications.

2. The Determinants of Health Status

Health, education and income are three important dimensions of wellbeing. In the economic literature there is consensus on the existence of a positive association between them. However, the direction of causality is not very clear, because of the existence of

[3] As Kiuila and Mieszkowski (2007) argue, the general biological deterioration is reflected by the significant increase of the incidence of various diseases after the age of 65 and by the general deterioration of physical robustness during old age, which reduces the impact of socioeconomic factors on health status and mortality.

reverse effects or other factors that can influence simultaneously education, health and income.

Since in this study our aim is to estimate a health production function, we are interested in analysing the impact of education and income (along with other factors that represent lifestyles) on health improvement. On the other hand, we want to highlight the causality effects among health, education and income.

There are well established conceptual links between education and health[4]. Increased education, as human capital theories predict, makes individuals more productive. Higher education in developed countries is associated with better jobs and better wages[5] which allow for better health care and provision. Skilled individuals usually have safer jobs (as they do more intellectual than physical work) and better work conditions[6]. On the other hand, more educated people are more informed and aware of the risks of adopting less healthy lifestyles. Several studies also show empirical evidence of a direct link between the education level of mothers and the health status of their children (Buor, 2003).

Individuals with higher levels of education also have a more efficient use of health care resources. The adoption of a health-seeking behaviour is associated with health literacy. At the same time, societies with higher levels of tertiary education also invest more in research and development (R&D), including the health sector. As Ricci and Zachariadis (2008) note, a country's absorptive capacity for health-related technology and ideas is improved by a higher average level of education in the economy. According to these authors it is also expectable that physicians will adopt and implement new treatments to the general population where the average patient is more educated, since he is more receptive to new medical knowledge.

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4 The relationship between education and health has been shown by several authors (Cutler and Lleras-Muney, 2006; Albert and Davia, 2007 among others).

5 In the latest OECD's *Education at a Glance 2009* report, data show that earnings for those with tertiary education relative to upper secondary education provide a good measure of the supply and demand for individuals with higher education, as well as the incentives to invest in higher education. Some countries have experienced a significant increase in the earnings premium for tertiary educated individuals over the period 1997-2007. Another important conclusion is that earnings increase with each level of education and that the earnings premium for tertiary education is substantial in most countries, exceeding 50% in 17 out of 28 countries.

6 See Arendt (2005), for instance, for an analysis of the impact of education on health status when the individual has already completed his investment in education and entered the labour market.

It is pertinent to assume that the relation between health and education is bidirectional. More educated people are healthier for reasons we explained above, but healthier people are able to accumulate more knowledge over the life cycle. Therefore, education must be assumed endogenous when a health equation is estimated.

Another important determinant of longevity is income. Higher income is also associated with better health. It allows individuals to have a better quality of life, which can be related to a healthier nutrition and greater access to health care products and services with positive consequences on health. It is important to note also that the relation between health and income is reciprocal with feedback effects and cumulative characteristics; higher income implies better health, and healthier people are normally wealthier since they are able to have better jobs and better payment. Therefore, the income variable has to be considered as endogenous in the health equation.

However, as Kiuila and Mieszkowski (2007) note, it is expectable that, as people get older, these socio-economic factors tend to have less importance in explaining mortality rates. As they point out, there is a selection process at younger ages which results in the narrowing of the mortality differentials of different socioeconomic groups after the age of 65.

The numerous studies that concentrate their analysis on the determinants of the health outcomes both on individual and aggregate levels generally emphasize, beyond socio-economic factors, the role of health care resources and lifestyles[7].

Health care resources can be seen as a measure of a nation's development, the result of research and development (R&D), investment and capacity to satisfy the patients' needs. Countries with higher levels of tertiary attainment have more scientific production implying also higher advances in the health sector and medical science.

In what concerns lifestyles, it is well known the negative impact certain behaviours have on health: most chronic diseases, like obesity, diabetes or cerebrovascular diseases, also

[7] Some studies (in a microeconomic perspective) also include biomedical factors, such as blood pressure or cholesterol levels.

depend on behaviour choices[8]. Although there are also some important genetic/biological factors explaining the incidence of diseases, there is consensus on the critical role of behavioural risks on health. According to WHO (2005), the most important (and modifiable) risk factors are unhealthy diet and excessive energy intake, as well as, physical inactivity and tobacco use[9].

Economic literature that examines the determinants of health status usually does not offer many diversified methods. Most empirical studies follow the "production function approach" or the data envelopment analysis (DEA)[10]. The health production function approach considers healthcare resources, socio-economic and lifestyles factors as the main determinants of health status, and this is the approach which we adopt in this study.

There are mixed results especially in what concerns the impact of health care resources on health outcomes in the OECD countries.

Puig-Junoy (1998) studied the OECD countries for the 1960-1990 period, using DEA analysis and tobit regressions on panel data. Adopting life expectancy at birth as health output and the number of physicians, non-physician health care employees and number of hospital beds as inputs, they found empirical evidence that, for similar health outputs, non-efficient countries use on average 40% more inputs than efficient ones.

Or *et al*. (2005) showed that for 21 OECD countries, for the 1970-1998 period and using panel data regressions, the impact of health care measured by number of doctors on life expectancy at birth and at 65 age varies significantly across countries. They also found that the availability of advanced medical technology plays an important role too.

Shaw *et al*. (2005) , following the health production function for developed countries, found that pharmaceutical expenditures has a positive effect on life expectancy at middle and advanced ages. According to these authors, another important determinant of life

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[8] According to Lee *et al*. (2007), 50% of premature deaths are related to risky health behaviours, and 70% of disease burdens and costs are due to risky behaviours.

[9] Other risk factors for chronic disease include infectious agents, responsible for cervical and liver cancers, environmental factors (such as air pollution), which cause asthma and other chronic respiratory diseases. Psychosocial and genetic factors are also important (WHO, 2005).

[10] Data envelopment analysis (DEA) is a nonparametric method of estimation of the best practice frontier. DEA approach considers a convex production frontier and allows for the calculation of technical efficiency measures (which may be input or output oriented). See, for instance, Afonso and Aubyn (2006).

expectancy is lifestyles: they show empirical evidence that a decrease in tobacco consumption by about two cigarettes per day or an increase in fruit and vegetable consumption by 30% raises life expectancy approximately one year for 40-year-old females.

On the other hand, Nixon and Ulman (2006) using fixed effects panel regressions for the early 15 members of the European Union over the period 1980-1995, found that increases in health care expenditure are significantly associated with large improvements in infant mortality but only marginally in relation to life expectancy.

Afonso and Aubyn (2006) estimated a semi-parametric model of the health production function using a two-stage DEA approach for OECD countries. They show that inefficiency is strongly related to GDP per capita, education level and health behaviour (obesity and smoking habits).

In a recent study, Ramesh and Mirmirani (2007) analysed the health care system of 25 OECD countries, using a fixed-effects panel data model for the 1990-2002 period. They estimated two regressions, one for life expectancy and another for infant mortality. Their empirical results suggest that supply of physicians and education levels are highly significant and conditional factors for both life expectancy and infant mortality.

Ricci and Zachariadis (2008) in a cross sectional analysis of 71 countries found empirical evidence that higher education is a significant determinant of longevity and that it is more robust than female literacy, sanitation, spending on medicine and per capita income.

Jourmand *et al.* (2008) used two different approaches - panel data regressions and DEA analysis – to estimate countries' relative performance in transforming health care resources into longevity. Their empirical estimates suggest that potential efficiency gains might be large enough to raise life expectancy at birth by almost three years on average for the OECD countries, while a 10% increase in total health spending would increase life expectancy by three to four months.

An important technical issue in the health empirical literature is that the endogeneity problem of some of the determinants of health status has not been considered in great deal. The existence of this problem can affect the estimated results providing biased and inconsistent estimates. The health equation we estimate in this study and the estimation technique used take into account the endogeneity of the regressors providing more reliable results.

3. Model, Methodology and Data Description

In this paper we adopt a panel data framework, using some of the latest data from the OECD Health Data, 2009 report. The health production function is defined as follows:

$$\ln LE_{i,t} = b\ln\left(Incomepc_{i,t}\right) + c_1 \ln\left(Education_{i,t}\right) + c_2 \ln\left(Health\operatorname{Re}s_{i,t}\right) + \\ + c_3 \ln\left(Tobacco_{i,t}\right) + c_4 \ln\left(Alcohol_{i,t}\right) + \varepsilon_{i,t}$$

where, $\varepsilon_{i,t} = \alpha_i + u_{i,t}$ with α_i denoting the country-specific effects or measurement errors and $u_{i,t}$ refers to the idiosyncratic error term.

We estimate five equations[11]. The dependent variable, $LE_{i,t}$, represents the health status proxy considering first, life expectancy at birth for total population, for males and females, and alternatively, life expectancy at 65 years old and over for males and females. The determinants of health status are: the per capita income of each period, $Incomepc_{i,t}$; the average years of education of the population aged 25-64, $Education_{i,t}$; a proxy for the resources devoted to health care represented by per capita consultations[12], $HealthRes_{i,t}$,; and two variables reflecting lifestyles, namely, tobacco (% of population of age 15 and over who are daily smokers), $Tobacco_{i,t}$, and alcohol consumption (litters per capita of population of age 15 and over)[13], $Alcohol_{i,t}$, respectively.

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[11] The regressions were run on Stata 9.2. using xtivreg2, which implements IV/GMM estimation of panel data models with possibly endogenous regressors.

[12] *OECD Health Data 2009* defines doctors' consultations as the number of contacts with an ambulatory care physician divided by the population. It includes visits/ consultations of patients at the physician's office; physician's visits made to a person in institutional settings or discharge planning visits, made in a hospital or nursing home with the intent of planning for the future delivery of service at home; visits made to the patient's home. It excludes telephone contacts.

[13] Alcohol consumption is defined as annual consumption of pure alcohol in litters, per person, aged 15 years and over. However, it is important to mention that methodology to convert alcoholic drinks to pure alcohol may differ across countries: typically beer is weighted as 4-5%, wine as 11-16% and spirits as 40% of pure alcohol equivalent (OECD, 2009).

The choice of per capita consultations as a proxy for health care resources is explained by two reasons: it is a measure of an effective use of the resources (human and physical) available; on the other hand, it is a different proxy from those conventionally used in health literature (number of doctors, number of hospital beds, etc.), aiming to capture the efficiency of the health system[14]. The higher the consultations the better health care is provided to populations.

We estimate this equation using panel data for 17 OECD[15] countries (given by the subscript i) for which data are available, over the period 1980-2004. Table 1 explains the set of variables used in the empirical approach providing some elementary descriptive statistics.

Table 1. Descriptive statistics of the variables (17 OECD countries, 1980-2004).

Variable	Observations	Mean	St. Deviation	Coef. Variation	Min	Max
income	500	23870.40	5879.60	0.2463	10554.64	44224.89
education	498	10.69	1.61	0.1509	6.30	13.40
patents	500	106.71	111.50	1.0449	0.10	651.55
med.graduates	356	38.71	16.59	0.4287	11.40	121.00
tobacco	324	30.31	6.78	0.2236	16.20	50.50
tobacco (females)	325	24.73	7.03	0.2843	5.10	45.00
tobacco (males)	325	36.08	10.93	0.3028	15.00	70.80
alcohol	492	10.66	2.87	0.2691	4.60	19.50
health expend	477	1620.41	866.94	0.5350	276.00	6194.00
consultations	344	5.78	2.61	0.4517	2.40	14.80
life expectancy (LE)	494	76.76	1.93	0.0251	71.40	82.10
LE females	494	79.85	1.83	0.0229	74.90	85.60
LE males	494	73.62	2.12	0.0288	67.90	78.60
LE at 65 females	492	18.83	1.25	0.0665	15.70	23.30
LE at 65 males	492	15.08	1.19	0.0792	12.40	18.20

As we can see from Table 1, *patents*, *health expend* and *consultations* are the variables with higher relative dispersion. All variables are defined in logarithms so we can interpret

[14] Verhoeven *et al*. (2007), in an attempt to assess the efficiency of education and health spending in G7 countries, for the period 1998-2003 and following DEA procedures, used in their analysis, an index of 28 OECD countries' average ranks for number of hospital beds, physicians and health workers *per capita,* immunizations and doctors' consultations. One of the findings of this study was that more immunizations and doctors' consultations were associated with higher efficiency in the health sector.

[15] The countries included in the sample are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom and United States.

the estimated parameters as elasticities of life expectancy with respect to each of its determinants.

Having in mind the endogeneity problem, we need to instrument the explanatory variables referred to education and per capita income to obtain unbiased and consistent estimates in the regressions. These two determinants of health status are potentially endogenous since the more healthy people are the higher is the possibility to enjoy higher income and to invest more on education. The endogeneity tests for per capita income and education confirmed that these variables should be treated as endogenous[16]. The adequate estimation method that takes care of this problem is two step GMM using as instruments, total expenditure on health (per capita), number of medical graduates[17] per practicing physicians (per million) and the number of patents (per million). The patent ratio is used as instrument for education (and income as well), and this is an adequate choice since in the more developed countries higher levels of human capital related to innovation differentiate better these economies[18]. The choice of these variables as instruments is based on the statistical significance (at 5%) of the correlations between the endogenous variables (education and per capita income) and other variables that can serve as instruments, as we can observe from the results reported in Table 2.

Table 2. Correlation coefficients of pair of variables

Variable	***income***	***education***	***health expend***	***patents***	***med.graduates***
income	1,000				
education	0,6796*	1,000			
health expend	0,8837*	0,6060*	1,000		
patents	0,6832*	0,7826*	0,5746*	1,000	
med.graduates	-0,1238*	0,0995	-0,3350*	0,1778*	1,000

To test the validity of the instruments we used the Sargan-Hansen test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid (uncorrelated with

[16] The C-statistic used to test the exogeneity of income and education is 15. 794 (with a p-value of 0.0004) rejecting therefore the null hypothesis.

[17] Medical graduates are the "number of students who have graduated in medicine from medical faculties or similar institutions, i.e., who have completed basic medical education in a given year" (OECD, 2009). It excludes graduates in pharmacy, dentistry/ stomatology, public health and epidemiology and individuals who have completed post-graduate studies or training in medicine.

[18] For empirical evidence on this issue see Soukiazis and Cravo (2008).

the error term), and that the excluded instruments are correctly excluded from the estimated equation. A rejection of the null hypothesis questions the validity of the instruments.

We also performed tests for the orthogonality and redundancy conditions[19] of the instrumental variables. All the instruments used in our regressions are in fact exogenous and they revealed to be non-redundant, with the exception of medical graduates that revealed to be redundant in the specification of Models (2) and (4), as Table 3 shows. As Baum et al. (2007: 22) note, "if some of the instruments are redundant then the large-sample efficiency of the estimation is not improved by including them". However, excluding this variable from the instruments the estimation results are not satisfactory for these two models.

Inferences about error autocorrelation and homoskedasticity have been made too. The Wooldridge test for autocorrelation[20] rejects the null hypothesis of error independence, so we had to implement the bandwidth option[21] for correcting this problem. On the other hand, robust standard errors are obtained to take care of error heteroskedasticity.

The efficiency of the GMM estimators is checked through the Hansen's J statistic (shown in Table 3). The J statistic is consistent in the presence of heteroskedasticity and autocorrelation, testing in the null hypothesis the overidentification of all instruments.

4. Empirical Results

In this section we report our empirical results (Table 3) by applying two step GMM (fixed effects) which are efficient for arbitrary heteroskedasticity and autocorrelation and also gives statistics robust to heteroskedasticity and autocorrelation. Model (1) is the life

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[19] The C statistic (also known as "GMM distance" or "difference-in-Sargan" statistic) implemented using the *orthog* option, allows a test for a subset of the orthogonality conditions, i.e., it is a test of the exogeneity of one or more instruments; the "redundant" option allows to test whether a subset of excluded instruments is redundant. Excluded instruments are redundant if the asymptotic efficiency of the estimation is not improved by using them (Schaffer, 2007).

[20] xtserial command in STATA implements the Wooldridge test for serial correlation in the idiosyncratic errors of a linear panel-data model. According to Drukker (2003), this test has good properties in samples of moderate size.

[21] We used in our regressions the option bw(#), with # = 5 (around $T^{1/3}$). When GMM option is combined with the bw(#) option, the estimates are autocorrelation-robust. See Baum *et al*. (2007).

expectancy at birth for total population, Model (2) for females, Model (3) for males and Models (4) and (5) are the regressions for life expectancy of elderly people for females and males, respectively.

Table 3. Regression results from the health status equations (17 OECD countries, 1980-2004).

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
	Life Expectancy (total)	Life expectancy (females)	Life expectancy (males)	Life expectancy at 65 (females)	Life expectancy at 65 (males)
income	0.0484** (2.039)	0.0351* (1.736)	0.1011*** (3.480)	0.0403 (0.386)	0.2896*** (3.561)
education	0.1479** (2.137)	0.1559*** (2.801)	0.0465 (0.485)	0.6676** (2.394)	0.2573 (0.862)
consultations	0.0201** (2.114)	0.0283*** (4.088)	0.0071 (0.530)	0.0638** (2.019)	0.0208 (0.403)
tobacco	-0.0215*** (-3.371)				
alcohol	-0.0147** (-2.560)	-0.0107 (-1.511)	-0.0213*** (-3.185)	-0.0232 (-0.761)	-0.0477** (-1.980)
tobacco (females)		-0.0053 (-1.115)		-0.0042 (-0.217)	
tobacco (males)			-0.0264*** (-3.305)		-0.0429 (-1.325)
Number of observations	163	163	163	163	163
Number of countries	17	17	17	17	17
instrumented variables					
root mse	0.00468	0.00535	0.00538	0.0187	0.0179
R-squared	0.922	0.853	0.929	0.785	0.903
adjusted r2	0.910	0.830	0.918	0.751	0.888
F (p-value)	183.7	71.81	216.1	42.32	184.4
Number of excluded instruments	3	3	3	3	3
Underidentification test (p-value)	0.0530	0.1292	0.0521	0.1292	0,0521
Hansen J statistic (p-value)	0.7909	0.75	0.5019	0.6886	0.2789
Tests for the instruments					
patents					
C statistic (p-value)	0.7909	0.75	0.9263	0.6886	0.425
IV redundancy test (p-value)	0.005	0.0042	0.0043	0.0042	0.0043
health expend					
C statistic (p-value)	0.7909	0.75	0.5019	0.6886	0.2789
IV redundancy test (p-value)	0.0002	0.0003	0.0001	0.0003	0.0001
med. graduates					
C statistic (p-value)	0.7909	0.75	0.5019	0.6886	0.425
IV redundancy test (p-value)	0.0552	0.1171	0.0426	0.1171	0.0426

Notes:
*** p<0.01, ** p<0.05, * p<0.1
Robust t statistics in parentheses.
Instrumented variables: income; education.
Excluded instruments: Total expenditure on health per capita; medical graduates, per 1 000 practising physicians; number of patents per 1000 population.

As can be seen from Table 3, all estimated coefficients have their expected sign. Higher income levels, higher education and higher efficiency of the health system (through consultations) affect positively health standards prolonging life expectancy. On the other hand, unhealthy lifestyles related to alcohol consumption and tobacco have damaging effects on health reducing life expectancy. However, not all of the estimated coefficients are statistically significant or have the same impact across different ages or gender.

Life expectancy at birth

In what respects the life expectancy at birth for total population, Model (1), all the explanatory variables considered in the health production function show statistical relevance. The most significant result (at 1% level) comes from the tobacco variable having its expected negative impact on longevity. It is predicted that a 1% increase in the ratio of population (with 15 years old or over) who are daily smokers is responsible for 0.0215% decrease in life expectancy at birth, everything else remained constant. At 5% significance level, per capita income and education have a positive effect on life expectancy at birth and alcohol consumption a negative impact. Education is the explanatory variable with the greatest impact (in magnitude) on life expectancy. It is predicted that every 1% increase in the average years of schooling (of the population aged 25-64) is associated with 0.1479% increase in life expectancy, assuming that everything else is constant. This is in line with the human capital theory that predicts a high association between education and health, since more educated people are likely to have safer and better jobs enjoying higher income that permits to have better health care and provision. More educated people are better informed and aware of health risks adapting themselves to a healthier life style. New treatments and new developments on the health sector depend highly on the level of education that allows for higher research and innovation in this sector.

These results do not differ significantly from other studies, like those reported recently by Jourmand *et al*. (2008), although they used a different methodology and sample size[22].

Life expectancy according to gender

When we analyze life expectancy regressions for females and males, Models (2) and (3) respectively, it is evident that the various explanatory variables play a different role according to gender. In fact, while for females the determining factors of life expectancy are education and consultations (highly significant at 1% level), for males, income and lifestyles (consumption of alcohol and tobacco) are the most important factors, both on magnitude and statistical significance.

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[22] Jourmand *et al*. (2008) used Generalised Least Square (GLS) methods, with country-fixed effects, and when health care resources are measured by health practitioners, the sample covers 22 countries.

These results, although different from those obtained by Jourmad *et al*. (2008)[23], are not surprising. In developed countries there are some health differences between women and men that have been noticed for a long time. It is well known that women have higher life expectancy than men (as OECD Health Data shows)[24] and this is possibly related to education level and better use of health services as our evidence shows. However, women also experience higher morbidity than men. As Gambin (2004) explains, the types of illness and main causes of death are also different: while for men the main causes of death are cardiovascular diseases, cancers and accidents (possibly related to life style and income level as our evidence shows), for women they are breast cancer and cancers of the genitor-urinary system. These facts corroborate with the idea that "women live longer but are sicker than men"[25] which can explain, at least partly, the fact that women are also the ones who make a greater use of health care services and this can be related to education level.

There are also significant gender differences in what concerns labour market participation and income, widely examined by labour economics literature. Although, in recent decades there has been an increasing female participation in labour market, mainly in developed countries, there are still important inequalities related to professional opportunities. Studies on this area have shown significant differences in earnings between males and females, after controlling for other common characteristics[26].

In what concerns lifestyles, some risk behaviour like tobacco and alcohol consumption, are more prevalent among males. This can be explained by socioeconomic and cultural

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[23] When they use health spending as a measure of health care resources, the results are very similar across gender and age, with inputs having the expected sign and statistical significance. The exceptions are for tobacco and income that loose the statistical significance for females when life expectancy at birth is considered. At age 65, alcohol has no statistical significance for both men and women. In a similar analysis, but considering practitioners instead of health spending, only alcohol has a different impact at age 65, having statistical significance only for women.
[24] According to OECD Health Data (2009) at age 65, life expectancy for females is, on average, over 20 years, while for males it is almost 17 years.
[25] See Börsch-Supan *et al*. (2005).
[26] See Gambin (2004) for a review.

factors[27]. However, it is also true that since the 80´s some significant behaviour changes have been made across gender and countries.

According to WHO (2005), tobacco is the leading cause of preventable death in the world, being responsible for 4.83 million premature deaths worldwide in year 2000. Health problems related to smoking depend on the duration (years of smoking) and the intensity of use (number of cigarettes smoked). The main causes of death associated with smoking are cardiovascular diseases, chronic pulmonary diseases and lung cancer. Additionally, it is also associated to sudden infant death syndrome and respiratory problems in children.

Smoking has been identified as the major cause of preventable death in OECD countries. The daily smoking rate for adults aged 15 years and over was in 2007, on average, 23% for OECD countries. Between 1980 and 2004, the time period analysed in this study, the percentage of smokers in the male populations of all OECD countries has declined and the same trend was observed for women in most countries, with exception of Finland and France. As the decline in smoking has been more marked for men than for women, the gender gap is narrowing, as data show for 16 OECD countries, for which unbroken time series are available from 1980. In 1980 the gap was 18% but had narrowed to 7% by 2004 (OECD, 2006; OECD, 2009a).

Excessive alcohol consumption is considerable in most parts of the world and responsible for high levels of morbidity and mortality. As OECD (2009a) points out, it is associated with the risk increase of heart stroke and vascular diseases, liver cirrhosis and certain cancers. Foetal exposure to alcohol also raises the risk of birth defects and intellectual problems. Excessive alcohol consumption is also often associated to death and disability caused by accidents and injuries, and assault, violence, homicide and suicide. According to OECD (2009a), it is estimated to cause more than 2 million deaths annually. Nevertheless, like tobacco, it is one of the major avoidable risk factors for disease.

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[27] Sassi *et al*. (2009) suggest that men and women in poor socio-economic conditions may differ in their lifestyle choices. As they point out, rates of smoking or alcohol abuse are higher among men at the bottom of the social ladder.

OECD Health Data does not give information by gender. So, we can only analyze trends in alcohol consumption across countries. There has been a reduction in alcohol consumption in the OECD countries over the period of analysis, which can reflect a changing of drinking habits but also the policy responses to control alcohol use. In fact, some of the implemented measures to reduce alcohol consumption, such as curbs on advertising, sales restrictions and taxation, have proven to be effective. Nevertheless, it has been observed in some countries and social groups (mainly among young males) a rise of consumption of large quantities of alcohol at a single session, termed "binge drinking" (OECD, 2009a).

Many of the negative consequences of risk behaviours on individuals' health are observed only some years later. In what concerns the alcohol consumption, data shows in general, that countries with high levels of alcohol consumption tend to experience higher death rates from liver cirrhosis 10 to 15 years later compared with countries with lower levels of consumption. In most OECD countries, death rates from liver cirrhosis have fallen over the past two decades, which can be related to the overall reduction in alcohol consumption (OECD, 2009a).

Life expectancy of elderly

When we look to the estimation results of Models (4) and (5) explaining life expectancy at age 65 for females and males, respectively, we can conclude that the major determinants of longevity for women and men are different. While for women education and consultations are the most significant factors (at 5% level), for men per capita income (at 1% level) and alcohol consumption (at 5% level) are the major explanatory factors. Some of these results (positive effect of consultations for women, negative impact of tobacco for men) are in line with the tendencies described above concerning the health status of the OECD countries.

However, we should look to these results with some caution since it is after this age that the incidence of various diseases increases sharply as well as the general deterioration of physical robustness, characterizing the biological deterioration process we have already referred. Therefore, it is expectable that at this age, health status of individuals also will reflect the cumulative effects of their lifestyles in earlier periods. This would imply the estimation of a dynamic panel model with a long lag history of the variables used in the health production function reducing the sample size drastically. On the other hand, data relative to tobacco consumption does not provide information about the quantity of cigarettes smoked on average per person but only about the proportion of population who is daily smoker, which is less relevant for the analysis of the impact of smoking on health.

5. Conclusions

The aim of this study is to analyze the main determinants of health status in the OECD countries. Life expectancy at birth and for elderly people (aged 65 and over) are used as proxies to express health improvements in these countries. Life expectancy is also considered for males and females to verify whether there are differences on the factors explaining health status according to age or gender. A panel data approach is employed to estimate the health equations that take into account the endogeneity of some determinants of health, such as, income and education. Two step IV-GMM which is efficient for arbitrary heteroskedasticity and autocorrelation is the adequate technique to obtain more consistent estimates. The endogeneity of some of the determinants of health status has not been considered in great deal in the empirical literature, therefore, our estimates are more reliable.

The health production function approach we use considers health care resources (through consultations), socio-economic factors (such as income per capita and education levels) and lifestyles characteristics (such as tobacco and alcohol consumption) as the main determinants of health status. The number of consultations (per capita) aims to capture the efficiency of human (and equipment) resources in the health system as an alternative to the conventional variables used related to number of physicians, hospital beds, among others. Total expenditure on health (per capita), number of medical graduates and the patents rates (as proxy for innovation) are the variables used to instrument income and education which are assumed (and shown) to be endogenous in the health equation. These instruments, both from the theoretical point of view and testing their validity are shown to be adequate in the estimation process.

Our empirical analysis shows that all socio-economic and lifestyles factors used (income, education, consultations, tobacco and alcohol consumption) are relevant in explaining life expectancy at birth for total population in the OECD countries. Education is the factor with the highest positive impact on health and non-healthy behaviour reflected in the consumption of tobacco the most significant factor (at 1% level) with negative impact on life expectancy.

However, when we do the same analysis by gender we obtain different impacts of the explanatory variables. While for women the determining factors of life expectancy are education and consultations, strongly significant at 1% level; for men, income, alcohol and tobacco are the most important factors explaining life expectancy. These results are in line with the statistical tendencies observed in the OECD data, namely, the higher life expectancy of females which can be attributed to education and better use of health services, relatively to the lower life expectancy of the males which can be due to unhealthy lifestyle behaviour.

The same conclusions are obtained with respect to life expectancy of elderly people (aged 65 and over). Once more, our findings suggest that for women, education and consultations are the most significant factors, while for men per capita income and alcohol consumption are the major explanatory variables. However, since the lack of data does not allow us to consider in our estimations the cumulative effects of individuals' lifestyles, we should look to these results with some caution. At the same time, these results evidence the need of more data concerning health conditions of the elderly, allowing for international comparisons.

Our study highlights that the main determinants affecting population health are associated with income levels, education, efficiency of the health system and lifestyle characteristics. Economic policies have to be implemented aiming to improve the standards of living and narrowing income disparities. Income policies that reduce disparities have a direct impact in improving health conditions and prolonging life expectancy. Education policies are crucial with this respect affecting both, income and health improvements and this has been well developed by the human capital theory. More educated people are wealthier and healthier. Investing on the health sector with the aim to improve efficiency is very important too and economically favourable, creating more jobs and economic activities associated to health sector. Finally, policies to alter unhealthy behaviour (through taxation, education and better information) are necessary for the sick of better health. It is important to highlight the strong association between health, education and income with cumulative characteristics and the necessity to develop policies that tackle these areas simultaneously.

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Appendix

Description of the variables and data sources

• $income_{i,t}$ is real GDP per capita (Laspeyres), RGDPL – dollars in 2000 constant prices. This data was collected from Heston *et al*. (2007), available at http://pwt.econ.upenn.edu/.

• $education_{i,t}$ is the average years of education of population aged 25-64, collected from Arnold *et al*. (2007), available at http://www.olis.oecd.org/olis/2007doc.nsf/linkto/eco-wkp(2007)52.

• $patent_{i,t}$, the patents ratio, is the number of patents per million of inhabitants aged 25 or over. Data on the number of patents was collected from the U.S. Patent and Trademark Office (USPTO), available at http://www.uspto.gov.

• Data on the number of inhabitants was collected from LABORSTA, Economically Active Population Estimates and Projections 1980-2020, Topic: Population and Economically Active Population (version 5), available at: http://laborsta.ilo.org/.

• Data on $consultations_{i,t}$, $tobacco_{i,t}$, $alcohol_{i,t}$, $med.\ graduates_{i,t}$, $health\ expend_{i,t}$, $life\ expectancy_{i,t}$ (at birth, total, females and males, and at age 65, females and males) was collected from OECD Health Data 2009, available at http://www.oecd.org/health/healthdata.

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