International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Evidence on the Association between Socioeconomic Resources and Amenable Mortality

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ABSTRACT

Background: There is growing interest in finding an indicator for health system performance that is directly related to health system expenditure and improvements in population health. This paper analyses the relationship between socioeconomic circumstances of countries and avoidable mortality.
Material and Methods: Six countries were selected: Germany, Spain, France, the United Kingdom, Sweden and the Netherlands. We studied the elasticity between avoidable mortality and different determinants of health.
Results: The elasticity between avoidable mortality and health expenditure per capita was heterogeneous among the different countries, with values ranging from –0.2 (Spain) to –0.95 (Germany).
Conclusions: This study confirms the existence of a negative relationship between the rates of avoidable mortality and health spending in the countries with 2-yearlag. As a rule for policy implications, avoidable mortality rate is a good indicator of health expenditures per capita and health systems effectiveness.

Keywords: Outcome assessment, quality indicators, quality improvements

INTRODUCTION

In specialized literature, there is some consensus around the idea that health systems in developed countries should be able to avoid certain causes of death. [1] These causes correspond to pathologies whose control is supported by a clear, evidence-based scientific process that is both effective and appropriate. There are numerous examples of these pathologies, whether they are communicable diseases that can be prevented through vaccination, diseases like cervical cancer that can be detected and treated at early stages, or chronic illnesses like hypertension for which effective medications exist.

This focus on "avoidable mortality" led Rustein and others to propose a list of avoidable causes of death in 1976. [2] It serves to measure the effectiveness of health systems in different countries, given that the interventions that help avert these deaths originate throughout the healthcare system, including in primary care, hospital care and population-based health services for screening and other public health functions. [3]

Since the publication of Rustein's list and the first approaches to the use of "avoidable causes of death" as an analytical strategy to evaluate health system effectiveness, there has been debate about which causes of death can most clearly reflect system performance. This controversy has given rise to various adaptations of the list in different spheres. [4-6]

However, the validity of "avoidable mortality" as an indicator of health system effectiveness has been challenged on several occasions. Some studies refer to these causes as "medical care indicators" or more often "health policy indicators", even though Rustein's original list was designed to evaluate healthcare quality in a given moment and in a specific setting.

In this context, the AMIEHS research group carried out a process of selection and double validation of potentially avoidable causes of mortality, ratifying them as indicators of efficacy for health systems. [7] The study consisted of an empirical validation analysis of the trends observed in mortality due to certain causes in relation to the improvements implemented in different countries' health systems, followed by a Delphi process among a panel of experts to validate the outcomes. Finally a definitive list, specifically designed for its sensitivity to measure improvements in health system performance in an international context.

The motivation for the present study resides in the intense debate around the evidence linking national income level and population health status. [8] There is a gap here between the efficacy of the health system and the national income level. Both may effect health but they are not the same thing and the mechanisms are quite different. This is a crucial point in the development of the argument where one could say what the main research question is and why health expenditure and AM have been chosen to study it.

The influence of these socioeconomic conditioning factors in health has been analyzed in some papers; [9] some studies use individuals' income level as the variables, [10-14] while others consider educational level, [15-17] and the general level of economic development in the country. [18]

Thus, there is an intense debate about which of the aggregate variables best reflect socioeconomic status (SES) [19] and how decisions on health expenditure influence the population health. [20-21]

The aim of this paper is to study the effect of health expenditure on avoidable mortality controlling for country socioeconomic level and to obtain a percentage measurement on the relation between the variables considered (elasticity), both as an average for all countries and for each country individually.

MATERIALS AND METHODS

To obtain empirical evidence on the relationship between decisions on aggregate health expenditure and the indicator of health system effectiveness, taking into consideration the socioeconomic determinants of health, three types of variables are used: data on avoidable mortality rates for certain causes of death, diverse indicators of health expenditure, and socioeconomic control variables.

Avoidable mortality rates obtained from several of the countries participating in the AMIEHS study (France, Germany, the Netherlands, Spain, Sweden and the UK). Data from their respective national statistical agencies covered the total population in all countries studied from 1970 to 2013. It should also be noted that data from both West Germany and the unified Germany were considered (the implications of this choice are discussed below). Table 1 presents the list of avoidable causes of mortality and some key interventions.

There are 25 series that correspond to standardised mortality rates (deaths per 100000 population), disaggregated by sex for every country, including three causes that only affect one sex (2 series for women and 1 for men). The rest affect both sexes (11 causes per sex, for a total of 22). For each country, a total standardised avoidable mortality rate was obtained.

Table 1: List of avoidable causes of mortality and main key interventions

CODE	Cause	Key intervention(s) that contributed to mortality decline
042-044	*HIV	Azidothymidine (AZT)
153, 154	Malignant colorectal neoplasm	A combination of specific treatments and improved management of the disease process, i.e., screening
180	Malignant neoplasm of cervix uteri	Screening programmes.
186	*Malignant neoplasm of testes	Advanced in surgery and adjuvant treatment, i.e., cisplatin.
201	Hodgkin's disease	Combined chemotherapy
390-398	Rheumatic heart disease	Combined treatment; antibiotic and advanced surgical techniques.
401-404	Hypertension	Antihypertensive drugs.
410-414	Ischemic heart disease	A combination of specific treatments and improved management of the disease process i.e. beta-blockers.
428-429	Heart failure	A combination of specific treatments and improved management of the disease process.
430-438	Cerebrovascular disease	Treatment of hypertension.
531-532	Peptic ulcer	H2 blockers.
584, 585, 586	Renal failure	Renal transplantation and dialysis.
745-756	Congenital heart disease	Improved surgical technique e.g. Deep hypothermia and circulatory arrest (DHCA).
760-779	*Conditions originating in the perinatal period	Incremental introduction of a wide range of treatments, e.g., special care baby units.

* Exception to the codes rule; HIV was not classified under the 9th revision of ICD.

To analyse the relationship between indicators of health expenditure and the indicator of health system effectiveness, it is essential to consider the socioeconomic aspects that may influence population health.

Statistical Analysis: For the variables with a complete dataset, a process for detecting outliers was applied, isolating those related to events outside the focus of the study. Perhaps the clearest example is the unification of Germany in 1991. To avoid the distorting effects of these changes in the results, we filtered them out of the affected series using a widely accepted procedure from the area of time series analysis, based on ARIMA models. [22]

One of our objectives was to calculate the elasticity between health expenditure and the socioeconomic variables with regard to avoidable mortality, both as an average for all countries and as a value for each individual country. Elasticity was considered the effect of a unit change in, e.g., health care expenditure on the rate of amenable mortality.

To establish the relationship between the socioeconomic dynamic observed through the variables studied in the different countries and the avoidable mortality rates, several panel models [22-23] were specified and adjusted; these models consider differences between countries throughout time and include time lags for the variables included, following on from the idea that "major changes in the health sector take time".

These models show the relationship between some of the socioeconomic variables considered, the health expenditure and the avoidable mortality rates. We use the Akaike information criterion (AIC) to compare and select models; the less the AIC the less information lost when using that specific model and the best quality achieved. Through a systematic analysis, various panel models were constructed, considering the avoidable mortality rate to be an endogenous variable. On the other hand, exogenous variables included health expenditure, along with several combinations of covariates selected from the SES indicators in different areas (income, health and population), including those with different time lags. There have been several major advances in the theoretical literature of panel data analysis over the last ten years but we followed Hsiao schedule, [24] we detected the presence of panel effects, or random effects in each country.

The models finally specified were as follows:

$amlisp_{it} = \alpha + \beta_{it}hcap + \beta hcap_{it-1} + \beta hcap_{it-2} + \beta sch + \beta gdp_{it} + \beta_{it}popu + \theta_i + \varepsilon_{it}$ (1)

$amlisp_{it} = \alpha + \beta_{it}hcap + \beta hcap_{it-1} + \beta hcap_{it-2} + \beta sch_{it} + \theta_i + \varepsilon_{it}$ (2)

$amlisp_{it} = \alpha + \beta_{it}hcap + \beta hcap_{it-1} + \beta hcap_{it-2} + \beta_{it}gdp + \theta_i + \varepsilon_{it}$ (3)

$amlisp_{it} = \alpha + \beta_{it}hcap + \beta hcap_{it-1} + \beta hcap_{it-2} + \beta_{it}popu + \theta_i + \varepsilon_{it}$ (4)

where: amlisp is the avoidable mortality rate calculated for each country; α signifies the average effect; hcap is the per capita health expenditure variable; sch is the average years of schooling; gdp is the Gross Domestic Product per capita; popu is the proportion of urban population; $\theta_i$is the country effect, considered to be the random variable; and $\varepsilon_{it}$is the residue of the model.

In models where the specification includes auto correlated variables with heterogeneous variations between the individual countries, estimators were obtained using the Generalized Method of Moments proposed by Arellano and Bond for panel models. [25]

RESULTS

Figure 1 shows the evolution of the AM as well as the health expenditure per capita in each of the countries studied for 1970–2013. The avoidable mortality rates decline steadily over the study period, while per capita health expenditure pregressively increases.

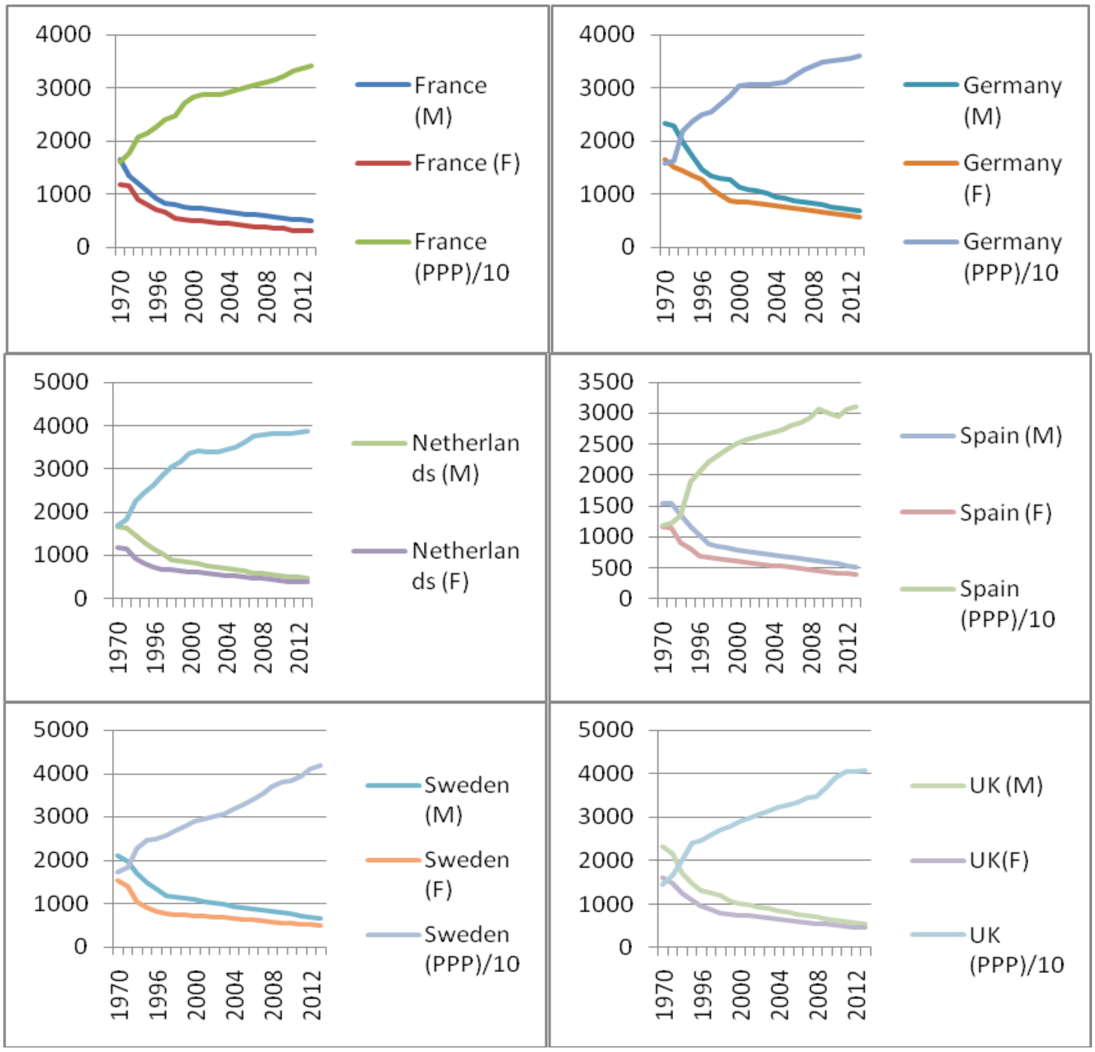

Figure 1: Avoidable Mortality rate per sex (per 100,000 inhabitants) and Total Health Expenditure per capita by country and Income per capita (1970–2013).

Note: Avoidable Mortality Rate (M: men and F: female); PPP/10: GDP per capita, PPP (constant 2005 US$). Source: Own Elaboration.

If we study the growth rate of each year (Figure 2) compared to the first year of study (1970), which allows us to see whether the variation patterns (growth in all indicators except for mortality rates, whose line should be interpreted as a decrease in the rate) have remained stable throughout the study period. We can observe that the health expenditure in Germany grew steadily, while in Spain, increases in health expenditure per capita slowed down until 1990, when the growth in expenditure started to exceed that of 1970. For its part, France accelerated its rate of growth starting in the 1980s, and the UK did so in the 1990s. Data from the Netherlands show an exponential growth dynamic in health expenditure per capita, and expenditure in Sweden is characterized by a cyclical pattern, with growth rates rising throughout the 1970s, pausing in the 1980s, and resuming a faster pace in the mid-1990s and up to the end of the study period.

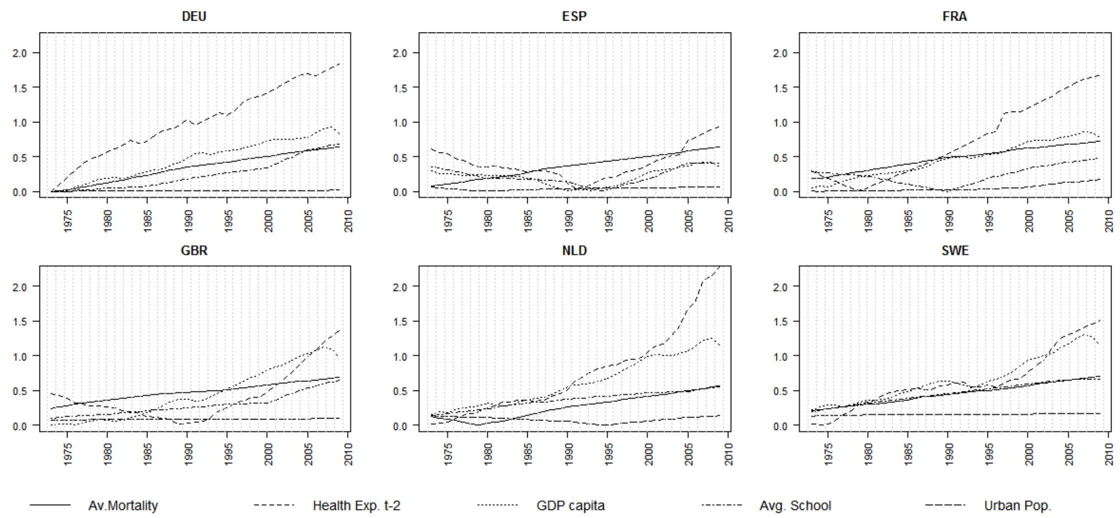

Figure 2: Growth rate of avoidable mortality, health expenditure per capita lagged two years, average years of schooling, GDP per capita and population in urban agglomerations from 1970 (percentages).

Note: Av. Mortality: avoidable mortality, hcap t-2: health expenditure per capita lagged two years; sch: average years of schooling; GDP: GDP per capita; popu: population in urban agglomerations, DEU: Germany, ESP: Spain, Fra: France, GBR: United Kingdom, NLD: Netherlands, SWE: Sweden.

Table 3: Panel Models considering avoidable mortality rate per country, health expenditure and socioeconomic indicators.

	Model 1		Model 2		Model 3		Model 4	
α	3773.09	***	2183.13	***	2084.95	***	2350.49	***
hcap	0.13		-0.24	*	0.03		-0.14	
hcap (t-1)	0.07		0.17		0.14		0.19	
hcap (t-2)	-0.17		-0.19		-0.38	**	-0.42	**
sch	-0.03	***	-72.72	***				
gdp	-82.43	***			-0.02	***		
popu	-17.78	***					-7.84	*
Random effects by country (θ_i)								
θ_{DEU}	23.91		223.83		193.16		241.18	
θ_{ESP}	-306.43		-227.82		-253.77		-177.50	
θ_{FRA}	-224.00		-173.26		-94.77		-76.33	
θ_{GBR}	-47.08		-212.59		-207.49		-252.16	
θ_{NLD}	293.21		360.05		344.52		274.51	
θ_{Swe}	260.36		29.79		18.35		-9.68	
AIC	2636.05		2727.98		2738.24		2769.37	

Signif. codes: 0 '***' 0.001 '**' 0.01 '* 0.05.

Note: hcap: health expenditure per capita; hcap (t-2): with a two-year lag; sch: average years of schooling; gdp: GDP per capita; popu: population in urban agglomerations, θi: country random effect (DEU: Deutschland, ESP: Spain, Fra: France, GBR: United Kingdom, NLD: Netherlands, SWE: Sweden). AIC: Akaike information criterion.

These fluctuations do not correspond to the trend in the avoidable mortality rate, which follows a more even and constant line of descent. As for the line representing the health expenditure with a two-year time lag, it matches the pace of the evolution of the GDP per capita.

The average number of years of education rises gradually throughout the study period and in all the countries included; in Spain, this resembles the trend observed in the GDP per capita. Finally, the proportion of the urban population is basically stable but rises slightly in comparison to the values observed in 1970, which are barely perceptible on the graph. Table 3 shows the estimated results according to the parameters chosen for each of the specified models.

It is worth noting that health expenditure per capita was shown to affect avoidable mortality only with a two-year lag. In addition, the sign was consistently negative, although with very low coefficients. However, of the three analyzed (no lag, one-year and two-year lag), the two-year lag generally translated to the greatest coefficients, reaching a value of –0.42 in model 4. That is, each increase in health system expenditure produced a reduction in 0.4 units of avoidable mortality two years later. The GDP per capita and the percentage of urban population were also shown to be statistically significant, although not in all models studied; indeed, the former had the greatest effect of all of the variables tested, with a coefficient of 82.4.This means that for every increase of US$ 1000 in GDP per capita, there will be a reduction of 82.4 units of avoidable mortality, adjusted for the rest of the variables presented in the model.

Table 4: Elasticity accordingly to the different adjusted panel models, considering significant variables.

		$hcap_t$	$hcap_{t-2}$	sch	gdp	popu
Total						
Model 1			-0.3230	-0.7182	-0.7601	-1.3357
Model 2		-0.4917	-0.3698	-0.6337		
Model 3			-0.7360		-0.6657	
Model 4			-0.8023			-0.5892
By Country						
Model 1						
	DEU		-0.3815	-0.6635	-0.7047	-1.1759
	ESP		-0.2077	-0.5510	-0.5113	-1.2466
	FRA		-0.4001	-0.7226	-0.8861	-1.5439
	GBR		-0.2937	-0.8749	-0.8932	-1.6044
	NLD		-0.2971	-0.6353	-0.6858	-1.0080
	SWE		-0.3762	-0.9404	-0.9718	-1.6293
Model 2						
	DEU	-0.5739	-0.4368	-0.5854		
	ESP	-0.3211	-0.2378	-0.4862		
	FRA	-0.6075	-0.4581	-0.6376		
	GBR	-0.4543	-0.3362	-0.7720		
	NLD	-0.4559	-0.3202	-0.5606		
	SWE	-0.5650	-0.4307	-0.8298		
Model 3						
	DEU		-0.8694		-0.6172	
	ESP		-0.4734		-0.4478	
	FRA		-0.9117		-0.7760	
	GBR		-0.6692		-0.7823	
	NLD		-0.6771		-0.6006	
	SWE		-0.8573		-0.8511	
Model 4						
	DEU		-0.9476			-0.5188
	ESP		-0.5160			-0.5499
	FRA		-0.9938			-0.6811
	GBR		-0.7294			-0.7078
	NLD		-0.7380			-0.4447
	SWE		-0.9345			-0.7188

Note: hcap: health expenditure per capita; hcap(t); hcap (t-2): with 2-year lag; sch: mean years of schooling; gdp: per capita Gross Domestic Product; popu: proportion of urban population, θ_i: country effect (Deu:Germany, Esp: Spain, Fra: France, Gbr: United Kingdom, Nld: Netherlands, Swe: Sweden).

The fitted panel models (which only include the variables that were shown to be statistically significant and which always include health expenditure per capita two-year lag variables), demonstrate an inverse, statistically significant relationship between health expenditure and the avoidable mortality rate (table 4). This result remains consistent even when applying a contrast of significance for the parameters that is robust to the presence of autocorrelation and Heteroscedasticity in the residues of the models.

Elasticities computed here help us to interpret the intensity and direction (positive or negative) of the relation between avoidable mortality and the different variables considered. Interpretation is straightforward, for example, model 1 in table 4, shows elasticity –0.32 between health expenditure two years previous and the avoidable mortality rate, meaning an increase of 1% in health expenditure today, would produce a reduction in the avoidable mortality rate within two years of 0.32%.

When considering a specific country, that "average" elasticity (–0.32), may be slightly different. For example, Germany's elasticity is higher than the average (–0.38) and Spain's is lower (–0.21), according with table 4 results. This means that health expenditure has a higher (0.17 points) impact reducing avoidable mortality rate in Germany than in Spain.

Following this reasoning, and according to model 1 (which is the one showing the lowest Akaike value, meaning a higher quality performance, see table 3), health expenditure two years previous, scholarship level, GDP per capita and proportion or urban population increasing 1%, may reduce avoidable mortality 0.32%, 0.72%, 0.76% and 1.34%, respectively.

Considering particular elasticities computed per each country, model 1 shows health expenditure has the highest elasticity in France (–0.4%), Germany and Sweden (–0.38), and education shows higher elasticity (impact) on avoidable mortality in Sweden (–0.94%) and the United Kingdom (–0.87). Income shows an elasticity of –0.97 in Sweden, and around –0.9% in France, the United Kingdom and the Netherlands.

In this context, the elasticity seen in the proportion of urban population in model 1 should be highlighted, with values exceeding 1, and for countries, with the Netherlands obtaining values near –1 in Sweden and –1.6 in the United Kingdom. This evidence could point to effectiveness gains related to urban structures, where proximity to health services and resources could reduce avoidable mortality to a greater extent.

DISCUSSION

The search for valid indicators that represent the effectiveness of health systems has been a continuous focus of research. A valid performance indicator of health system effectiveness should be sensitive to health expenditure. Initially, investigations looked into the relationship between economic development and infectious diseases and childhood diseases. More recently, other pathologies were added to the list, including chronic illnesses and some types of cancer, [26] but to date, these have barely been studied, and evidence linking their control to core health system performance indicators is scarce.

However, most research has used mortality as the principle indicator of effectiveness, [10,11,14,18] especially with regards to trends observed in crude and adjusted mortality rates. However, this indicator is not ideal, even when it is standardized, given that it does not accurately measure the result of the health system, which performs many services aimed at improving quality of life or reducing disabilities. [26,27] This fact is especially evident in developed countries, where the most common diseases are chronic. Another widely used indicator is life expectancy at birth, [28] but this measure, like mortality, is limited by its ability to reflect the capacity of health systems to improve quality of life, although some studies do relate it to income. [29]

At a healthcare microeconomic level, sometimes there is evidence of a relationship between certain diseases and the results of clinical trials or specific technologies, [29] but its extrapolation to an aggregated level (country level) to obtain a cross-country comparison does not permit its use in a general context.

There have been some previous attempts to study the association between health expenditures and avoidable mortality at the national level. [30,31] However, it is interesting to note that the outcome indicator, analyzed through avoidable mortality as reported by the AMIEHS team, allows us to broaden our analysis of the impact of health expenditure and economic growth to a larger group of pathologies than traditionally considered.

With regard to the input factors used for measuring both the aggregate expenditure and other socioeconomic determinants of health, the most commonly used indicator has traditionally been GDP per capita, usually at PPP. [32] The main reason for this is the availability of a standardized calculation for a large group of countries, developed by widely recognized institutions, which confers a good level of conceptual and statistical consistency on the data. The analyses that use this indicator, however, tend to focus on the study of poverty and health inequities rather than health system effectiveness. For example, Deaton [28] showed that the effect of each additional dollar spent on health is weaker in wealthy countries than in poor countries, and Sterling et al [10] obtained an estimate of relative risk for poor health due to poverty. Likewise, Beckfield [12] analyzed the evidence supporting the effects of inequality on health.

It is worth noting that, observing the elasticities obtained for each country, the models are capable of capturing the differences in the magnitude of relationships between the rate of avoidable mortality and the variables considered. This heterogeneity is apparent in the magnitude effect of each variable estimated in the different models (elasticity in absolute terms). It should be highlighted that health expenditure per capita only affected avoidable mortality with a two-year lag, and in addition, the sign was consistently negative, if only with low coefficients. That said, of the health expenditures per capita analyzed, the two-year lag generally resulted in the greatest coefficients, reaching –0.4.

In the four models analyzed, we observe that the elasticities exceed 0.5 in almost all of the variables. However, there is consistent evidence in favour of the effect of education on health system effectiveness in the sample, with elasticities nearing 1 in all the countries studied. Income per capita is also shown to be influential, above all in model 2. The concentration of the population in urban areas could also be related to better rates of avoidable mortality due to increased coordination among health system structures that are nearer to each other. There is a strong association between education and income, partly because higher education provides better opportunities on the labor market [33] and these on education, prevention, and other that are important factor to reduce avoidable mortality.

However, although avoidable mortality appears to be a good indicator of health system performance at a national level, at a regional or local level it is less so, because the rates are much lower and no longer paint an accurate picture of performance, as some authors have noted. [34]

A summary the results of our study are consistent with some of our original hypotheses, such as that the variation in health expenditure is inversely related to the rate of avoidable mortality. Likewise, variations in income, educational level related to an urban environment also have a negative correlation with avoidable mortality. Moreover, the lagged variables introduced in the model show that health expenditure results in a two-year delayed effect on the avoidable mortality rate.

One limitation of our analysis deals with the consideration of a constant association between health expenditure and the avoidable mortality rate, when the long period of analysis (over three decades) probably conceals a more dynamic relationship. However, the tests applied to detect panel effects by period did not provide evidence for the inclusion of these effects in the model specifications. We believe that this is due to the existence of a more complex structure in the relationship between health expenditure and the socio economic covariates included.

CONCLUSIONS

Health expenditure per capita, with a two-year lag, is the factor that is related to the avoidable mortality rate in the countries studied, even when controlling for other socioeconomic factors. Our study suggests that the revised avoidable mortality is an adequate indicator for health policy measuring efficiency in health system expenditure.

ACKNOWLEDGEMENT: This study was partially supported by a grant from European Union's framework of the Public Health Program: "Avoidable mortality in the European Union: Towards better indicators for the effectiveness of health systems (AMIEHS)".

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How to cite this article: Alfonso-Sanchez JL, Mackenbach J, Hoffmannc R et al. Evidence on the association between socioeconomic resources and amenable mortality. Int J Health Sci Res. 2017; 7(4):370-379.

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