ORIGINAL ARTICLE

An overview of different health indicators used in the European Health Systems

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Keywords

Health systems • Europe • Health indicators • Health care performance

Summary

Introduction. *In the European Union three different health systems could be defined according to service delivery, financing, and economic policies: Beveridge, Bismarck and Mixed system. Although health systems are hardly to compare, various organizations are developing methods assessing performance. In the present work the performance of the three systems were evaluated using European Community Health Indicators according to Organization for Economic Cooperation and Development.*
Methods. *The study has been conducted among the 28 states of the European Union using the following indicators: Standardized death rate for diseases of the circulatory system, standardized death rate of malignant neoplasms, road traffic accidents with injury, life expectancy at birth, incidence of Human Immunodeficiency Virus (HIV), infant deaths, pure alcohol consumption, infants vaccinated against Diphtheria Tetanus Pertussis (DTP), public and total expenditure on health over the period 2001-2010.*
Results. *The variation of health indicators over the observational time shows similar trend of circulatory system diseases and malignant neoplasms death rates, road accidents with injury, infant deaths, life expectancy at birth, public and total health expenditure. Some differences in the trend of HIV incidence, alcohol intake and DTP vaccination rates arise among systems. Grouping countries by health system paradigm and geographical area, resulted in a relevant heterogeneity ($I^2 \geq 90\%$, Pvalue < 0.0001). No clear superiority of a given health delivery system was found with respect to other paradigms.*
Conclusions. *In accordance with the evidence of our study, it can be stated that best performances are more likely to be linked to country specific economic factors. In conclusion, it was not possible to identify the best health system model.*

Introduction

Health systems in the European Union are managed in a different way according to models of service delivery, financing, and economic policies. Three different systems could be defined. National health services (also referred to as "Beveridge" systems) are distinguished from social insurance systems (also referred to as "Bismarck" systems) with respect to the role of the state as financier and owner of facilities [1]. Different grading of mixed systems between the two is quite common worldwide [2-4].
The Beveridge model, first established in the United Kingdom in 1942, is financially granted by public taxes and the state directly finances structures. This model is also referred to as National Health System (NHS) and provides universal health coverage. In Europe this model is adopted by Cyprus, Denmark, Finland, Ireland, Italy, Latvia, Malta, Portugal, Spain, Sweden and United Kingdom [5, 6].
On the other hand, in Bismarck model (Germany, 1880), the financial funding of the health care system is granted through compulsory social security contributions by employers and employees. The management of the funds is exerted by no profit agencies. The State provides health care coverage to those who are not enrolled in the employment insurance fund. This model is also referred as Social Health Insurance System (SHIS) and is adopted in Belgium, Estonia, France, Germany, Lithuania, Luxembourg, Netherlands, Poland, Czech Republic, Romania, Slovakia, Slovenia and Hungary [5, 6].
In the Mixed model, private funding from voluntary insurance schemes or upfront payments is significant. This model is also referred as the Private Health Insurance System. European countries that have adopted this system are Austria, Bulgaria, Greece and Croatia [5, 6].
Health Systems are different and complex, therefore they are hardly to compare. Various Countries and international organizations studied methods for assessment of health system performance. The most interesting models of evaluation are developed by World Health Organization (WHO), Organization for Economic Cooperation and Development (OECD), European Community Health Indicators (ECHI) and Bloomberg L.P., a privately held financial software, data, and media com-

pany. The WHO index is built on following indicators: disability-adjusted life expectancy, responsiveness and fair financial contribution [7]. The OECD makes a correlation analysis between outcomes, resources and other determinants; it has not yet developed a real numerical index of evaluation but the individual determinants of health were assessed among its Member States [8]. The ECHI initiative started with the 1997-2002 EU Health Monitoring Program, pointed to get a harmonized picture of European health conditions [9]. Bloomberg L.P. propose an index where each country was ranked on three criteria: life expectancy, relative per capita cost of health care and absolute per capita cost of health care [10].
Nevertheless, every year different agencies define an official country ranking according to different health determinants, which of the three health care models is best performing is still under discussion. In the present work, the research group would evaluate and compare the performance of the three systems using European Community Health Indicators (ECHI) [9].

Methods

The research group conducted the study among the member states of the European Union (EU). The EU is a political-economic union of 28 countries established under its current name in 1993 by The Maastricht Treaty [11, 12].
To evaluate the three Health Systems, the following ten indicators were chosen from ECHI program [9]: standardized death rate for diseases of the circulatory system, standardized death rate for malignant neoplasms, road traffic accidents with injury, life expectancy at birth, incidence of Human Immunodeficiency Virus (HIV), infant deaths (health status indicators); pure alcohol consumption (health determinants indicator); infants vaccinated against Diphtheria Tetanus Pertussis (DTP), public expenditure on health, total health expenditure (health interventions and health service indicators).
The choice was based on the *usefulness rating of ECHI indicators* [13], an index obtained by a survey carried out among European policy makers, and on the availability in *WHO-Health For All database* [14] for the 28 EU member States at the time of research (September 2015). The health indicators have been collected for each country in a time frame of 10 years from 2001 to 2010.
Ethical approval was not required for this study.

Statistical methods

Indicators were described by country and by health system paradigm using median and interquartile range over the period 2001-2010. The logarithmic transformation was used for count variables while the arcsine transformation was used for rates when performing country-specific repeated measures models. Estimates by year were performed and used to remove linear trends and account for autocorrelation of the measures. Those values were meta-analysed by countries grouped in four main geographical areas defined as North-Baltic (Denmark, Estonia, Finland, Latvia, Lithuania and Sweden), Central-West (Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands and United Kingdom), Central-East (Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia) and South-Mediterranean (Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia and Spain). Overall heterogeneity given by country and geographical area was evaluated by health system paradigm using the Cochrane's Q test and the I^2 statistic. Source of heterogeneity were addressed using random effect meta-regression grouping countries by health system paradigm and geographical area. Thus, unrotated principal component based cluster analysis was performed using the Z-score value of the time de-trended variables during the period 2001-2010. Countries were plotted using the first two principal components scores and a dendrogram was used to report clustering among countries. Generalized Linear Models (GLM) of the first two principal components were interpolated with respect to health system paradigm, demographic, social and economic parameters and clusters previously identified.
All statistical evaluations were performed by SAS vers.9.3.

Results

The variation of health indicators over the observational time from linear regression analysis clearly shows a decreasing trend of cardiovascular diseases (CVD) and malignant neoplasms death rates, road accidents with injury, and infant deaths (Tab. I, Fig. 1). On the contrary, life expectancy at birth and health expenditure increases consistently despite health system paradigm. Some differences in the trend of HIV incidence, alcohol intake and DTP vaccination rates arise among country. Supplementary tables 1-10 reports health indicators changes over time by country.
Countries have been grouped by health system paradigm and geographical area and it has been reported the average and standard error over the observational period for all health indicators in Figures 2 and 3. According to these evaluations, it appears a relevant heterogeneity ($I^2 \geq 90\%$, P value < 0.0001) for all indicators with the exceptions of infant deaths and DTP vaccination rates, where differences by health system paradigm were not found according to paradigm and area random effect metaregression ($P_{Area} = 0.284$, $P_{System} = 0.806$).
Repeated measure analysis showed us the relation between determinants of the heterogeneity reported above and the interaction between factors, as geographical area, health system paradigm, and time. The relation between indicators and time was consistent with the exception of alcohol intake and infant vaccination against DTP. A significant interaction between CVD death rate, road traffic accidents with injury, life expectancy at birth, HIV incidence and both public and total health expenditure was found by within country analysis of variance. A statistical significant effect of the interaction between time and

Tab. I. Descriptive statistics of selected indicators by health system paradigm over the period 2001-2010.

	Bismarck		Mixed		Beveridge	
Indicator	Δ/year	Median (q1,q3)	Δ/year	Median (q1,q3)	Δ/year	Median (q1,q3)
SDR cardiovascular diseases x 100,000†	-12.31	325.8 (295.3, 354.8)	-12.88	374.4 (345.6, 413.2)	-9.65	235.7 (213.4, 259.3)
SDR malignant neoplasms x 100,000†	-2.07	190.9 (187.9, 197.2)	-0.60	173.5 (172.7, 173.9)	-2.56	163.2 (157.1, 168.6)
Road traffic accidents with injury x 100,000†	-3.80	193.8 (182.6, 200.3)	-2.69	229.2 (219.6, 231.2)	-6.94	214.3 (204.2, 238.8)
Life expectancy at birth (year)	0.33	76.48 (75.71, 77.24)	0.23	76.97 (76.35, 77.51)	0.32	78.93 (78.26, 79.70)
HIV incidence x 100,000†	0.17	3.23 (2.93, 3.76)	0.14	2.35 (1.96, 2.63)	-0.01	6.66 (6.27, 6.86)
Infant deaths x 1000†	-0.28	4.88 (4.13, 5.70)	-0.27	5.32 (5.01, 6.05)	-0.16	4.14 (3.79, 4.53)
Pure alcohol consumption litres x person	0.02	11.34 (11.27, 11.56)	-0.09	10.87 (10.68, 11.08)	-0.01	9.78 (9.47, 9.87)
DTP vaccination of infants (%)‡	0.11	97.6 (97.1, 97.7)	0.41	94.0 (92.7, 94.4)	-0.16	95.3 (94.8, 95.6)
Total health expenditure PPP$ x person	140.2	2255 (1934, 2612)	118.6	1993 (1711, 2379)	146.1	2451 (2111, 2856)
Public health expenditure PPP$ x person	98.1	1654 (1453, 1935)	94.2	1485 (1279, 1769)	121.6	1876 (1555, 2197)

Note: †log transformed and ‡arsin transformed to perform regression over time. Δ/year = variation by year performed by regression over time, Median (q1,q3) = median, first and third quartile of raw dataover the observational time (2001-2010). SDR = standardized death rate. HIV = human immunodeficiency virus. DTP = diphtheria tetanus pertussis. PPP = purchasing power parity

geographical area for circulatory system diseases death rate, alcohol intake and both public and total health expenditure was shown by within country analysis.

Multivariate clustering of countries

Principal component analysis of detrended variables over time resulted in two component corresponding to an overall 56.5% of explained variance: the first accounts for 33.2% of the variance and the second one for 23.3% (Fig. 4A).

The first component counterpoises CVD and cancer death rates having loadings of 0.42 and 0.35 respectively to health expenditure both total and public (factor loadings of 0.51 and 0.49 respectively); this component represent a general score ranking death prevention efficacy in terms of health expenditure.

The second component counterpoises CVD deaths and HIV incidence and infant deaths (with loadings of 0.31, 0.58 and 0.28 respectively) to cancer death rate, alcohol intake and life expectancy having loadings of 0.25, 0.24 and 0.56 respectively (Fig. 4B); this component seems to be related to a more specific score ranking countries according to early vs late deaths, with HIV incidence playing a role on the side of early death factors being probably related to behaviours at risk as a proxy.

According to those two components, the biplot (Fig. 4C) shows a clear cluster of countries with positive scores on the first component. Those countries having better health system performances (Ireland, Denmark, United Kingdom, Austria, Germany etc.) are opposed to less efficient countries (Bulgaria, Lithuania, Romania, Latvia, Estonia and Hungary) for which the health system performances are less brilliant. This pattern is graphically represented on the dendrogram reported on Figure 4D.

Discussion

Analysing the variation of health indicators over the considered period, it can be observed that some variables show the same temporal trend for the three systems. Although the cardiovascular diseases are the principal cause of death for EU28 member States (37.5% of all deaths) [15], standardized death rates were gradually decreased as the research group expected since the improving of specific treatments and therapies, and risk factors reduction (high blood pressure, high cholesterol level). Similar tendency is shown for standardized death rates malignant neoplasms, for early diagnosis thanks to secondary level prevention (*i.e.* screening tests). About HIV incidence, this indicator seems to be quite stable over the time. Therefore, according to the OECD Report [8] this result hides diverging trends across countries. For example, the newly diagnosis of HIV has nearly double in Greece and the other hand the rates have dramatically dropped in Estonia. All the countries have seen their alcohol consumption increase from 2001 to 2007 and then fall since 2008. Considering that the variation of this indicator reflects change in drinking habits and primary health care policies [8], the rise in unemployment caused by 2008 economic recession could have been associated with a decrease in alcohol intake [16]. All European countries have achieved remarkable progress in infant mortality rates, with an almost steady decline from 2001 to 2010. Infant mortality reflects socioeconomic conditions, health and individual lifestyles of mothers, as well as the quality and efficiency of the health system [17]. The reduction of infant death rate along with the reduction of mortality before the fifth birthday explain the significant overall increase of life expectancy at birth. Decreasing of death rates and rising of life expec-

Fig. 1. Trend over the observational time for the 10 indicators considered by health system delivery paradigm. Dotted line portray mobile mean interpolation (period 2).

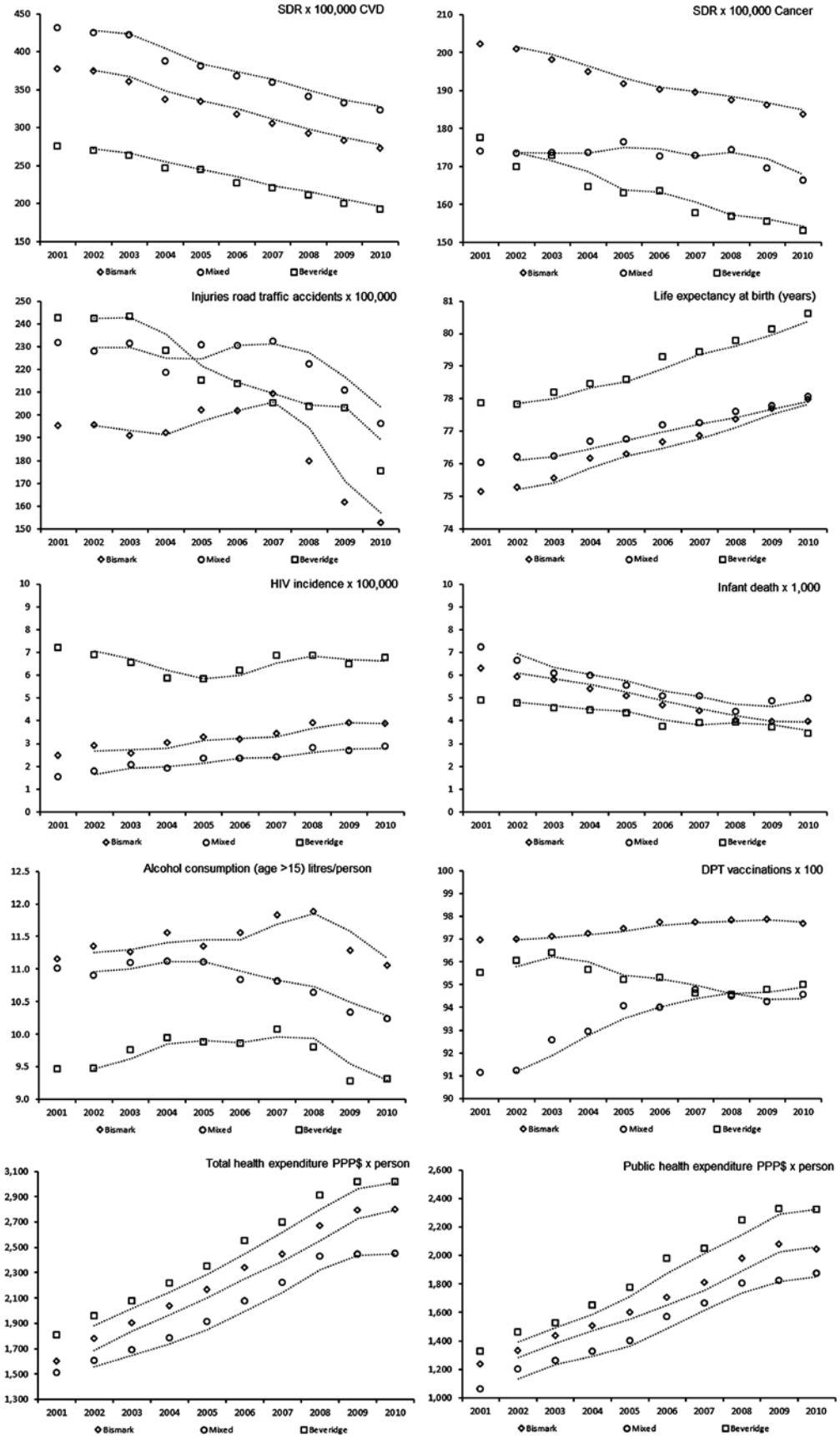


Fig. 2. Standardized Death Rate (SDR) for cardiovascular diseases (CVD) and cancer, Road traffic accidents (RTA) injuries, life expectancy and HIV incidence by health system paradigm over the period 2001-2010.

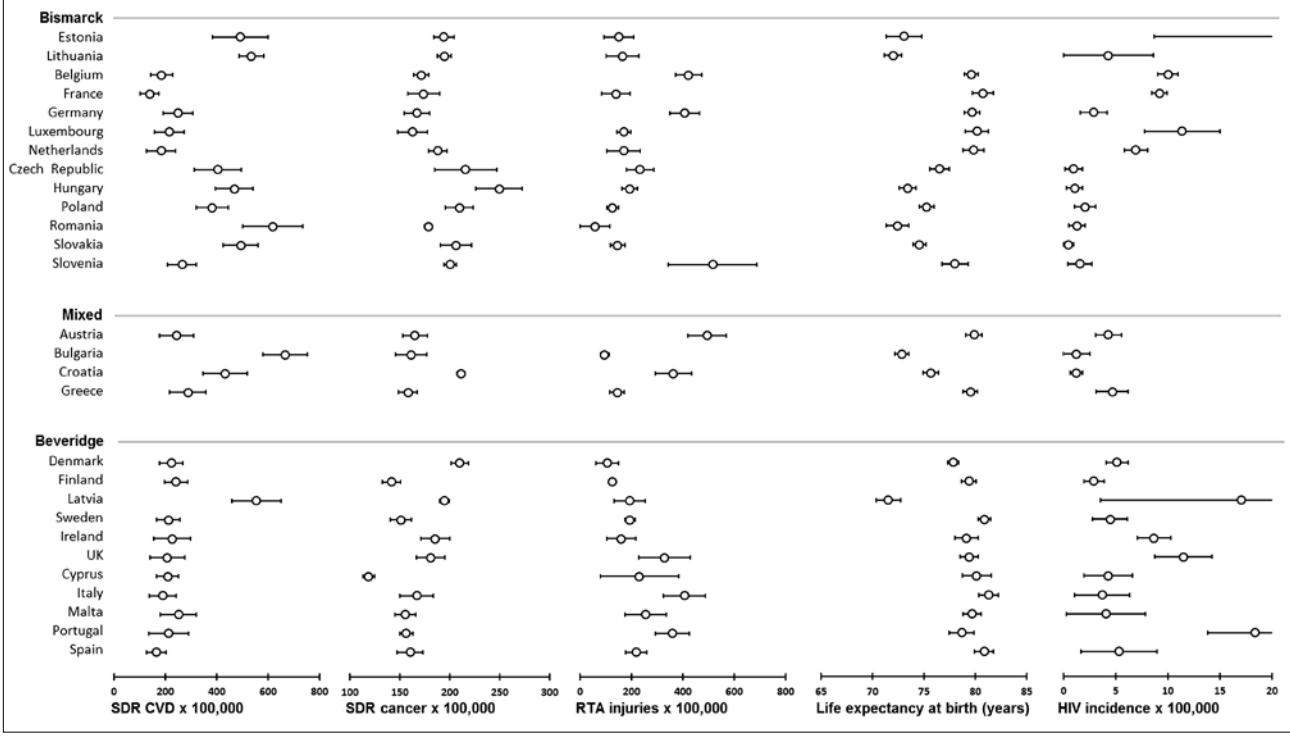
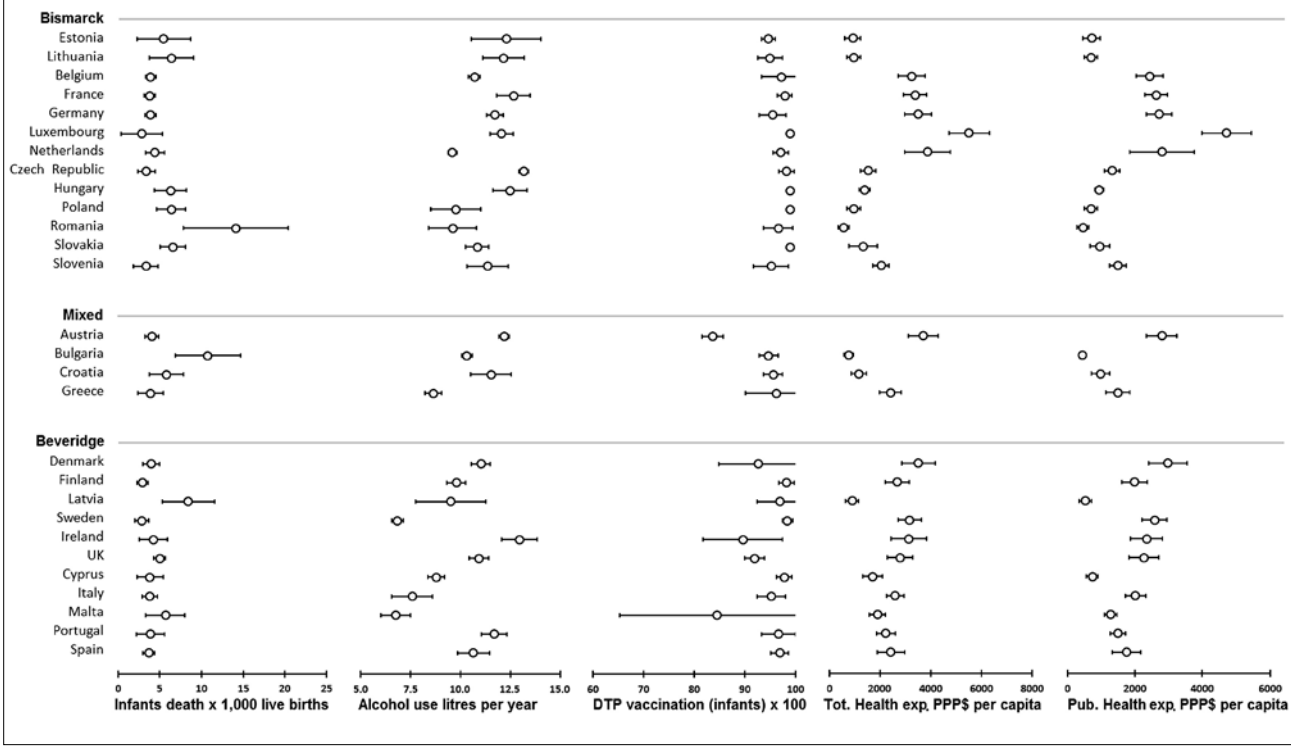


Fig. 3. Infant deaths, alcohol intake, DTP vaccination, and public health expenditure by health system paradigm over the period 2001-2010.

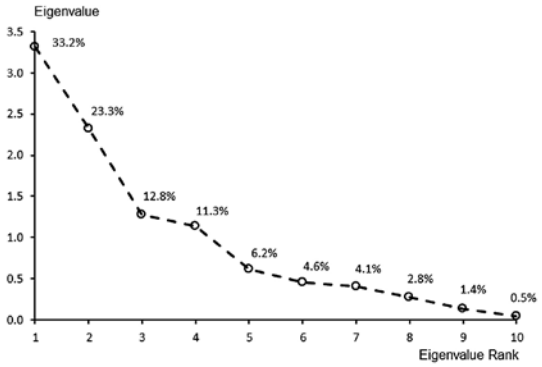


tancy have led to a substantial growth in the number of elderly people with chronic illness or disability. These conditions, together with advances in health care technologies could be considered as major determinants of the increasing in health expenditure [18] over the covering period.

With regard to road traffic accidents with injury and infants vaccinated against DTP, a high heterogeneity has

Fig. 4. Multivariate analysis of detrended indicators and country clustering.

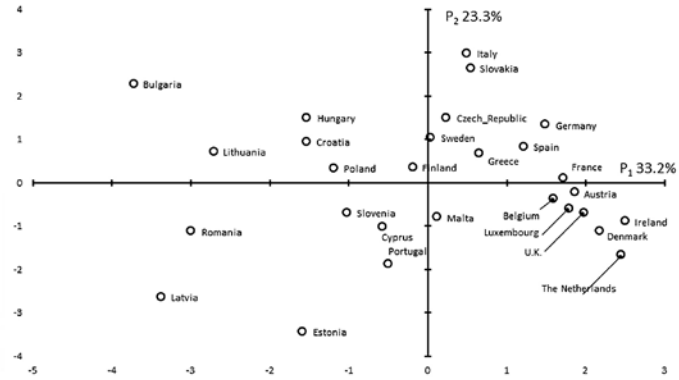
A) Eigenvalue plot. Eigenvalue explained variance by rank



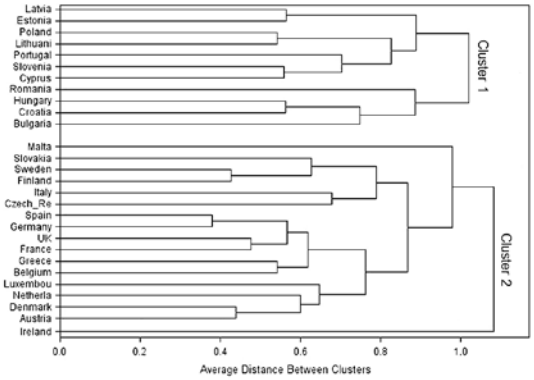
B) Variable loadings on the first three principal components

Indicator	L1	L2	L3
CVD deaths	-0.4244	0.3147	0.1167
Cancer deaths	-0.3544	-0.2507	0.0737
Road injuries	-0.0735	0.1573	-0.2193
Life exp	-0.0297	-0.5561	-0.2701
HIV incidence	-0.0569	0.5794	-0.0277
Infant death	0.3421	0.2788	0.3800
Alcohol use	-0.2016	-0.2430	0.4928
DTP vaccination	0.1567	0.1231	-0.6645
Tot health expenditure	0.5086	-0.0923	0.1283
Public health expenditure	0.4938	-0.0891	0.1177

C) Biplot of country scores over the first two components



D) Dendrogram of multivariate clustering



been observed in temporal variation intra and inter health system models. In presence of a large variety of vaccine offers, the vaccination schedules are programmed in different ways within Europe: DTP is mandatory in 9 of 28 EU state members (Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Poland, Romania, Slovakia and Slovenia) and in four more countries (France, Greece, Italy, Malta) only Tetanus and Diphtheria. In the remaining 15 nations DTP is recommended [19, 20]. Although mandatory vaccination may be a way to improve the compliance with vaccination program, it is not possible to highlight a plain overlap between high coverage and country that oblige DTP vaccination. Indeed, many other factors, as the use of combined vaccines and informative and promoting campaigns, may play a role in vaccination coverage. Both cultural and historical background shall be accountable for such variabilities [19]. Despite in the last few decades the incidence of road traffic accidents with injury was decreased, this decline has certainly happened unevenly throughout Europe. Road traffic accidents are primarily affected by several factors, such as alcohol consumption, vehicles utilisation rateand economic status, resulting in the fluctuation emerged in our data.

Conclusions

As final remarks, it can be affirmed that health system performance is not due to health system paradigm and proxies of the economic status of a country should be taken into account. In fact, as shown here, geographical area has more impact on the variability of such indicators as death rates for circulatory system diseases, alcohol intake and total and public health expenditure.

However, a limit of this study could be the decision to use in the research only the indicators that were up to date for all countries in the time frame selected. This was due to the unavailability in the European Health for All Database, of data concerning specific indicators for some countries.

Furthermore, it would be useful to perform alternative analysis taking into account other possible factors, as Gross Domestic Product, the time length of the permanence in the European Union and other demographic or socioeconomic indicators.

Therefore, in accordance with the evidence of our study, it is not possible to identify the best performing Health System. Nevertheless, the multivariate clustering analysis points out that the best performing countries are those in which the health expenditure is higher in absolute terms, regardless of their health system. Hence,

the study confirms that, as expenditures are important, so total health expenditure is a crucial part for a good performing health system. How the health expenditure could be evaluated in relative terms and how this may influence the health system efficiency is still an open question.

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Authors' contributions

MG conceived of and planned the study, performed statistical analysis and participated in the interpretation of results. FC planned the study, participated in the interpretation of results, draft the manuscript. LC made English language revision. GMS planned the study, participated in the interpretation of results, draft the manuscript. LG planned the study, participated in the interpretation of results, draft the manuscript. GB and GP made critical revision of the manuscript. CR conceived of and planned the study, performed statistical analysis and participated in the interpretation of results.
All authors approved the final manuscript.

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