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ORIGINAL ARTICLE

European Union state of health from 1990 to 2017: time trends and its enlargements' effects

João Vasco Santos[1,2,3] · Mariana Lobo[1,2] · Rui Manuel Neiva[1,2] · João Viana[1,2] · Júlio Souza[1,2] · Cláudia Camila Dias[1,2] · Jonathan Cylus[4] · Walter Ricciardi[5] · Alberto Freitas[1,2]

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Abstract

Objectives We aimed to study health status' time trends in the European Union (EU) during 1990–2017 and its enlargements' impact.

Methods Using estimates from the Global Burden of Disease 2017 study and calculating age-sex-standardized rates, we have described time trends and analysed the differences between EU groups regarding the state of health. Interrupted time-series analyses were also performed in order to assess the enlargement impact in the EU state of health.

Results All age–sex-standardized rates (mortality, years of life lost, years lived with disability and disability-adjusted life years) declined (annualized rates of change of − 1.7%, − 1.52%, − 0.06% and − 1.01%, respectively) between 1990 and 2017 (except between 2014 and 2015). For EU-28, life expectancy and healthy life expectancy increased 5.9 and 4.6 years, respectively. With the EU-25 and EU-27 enlargements, all age–sex-standardized rates and life expectancies worsened (with statistical significance). The EU-28 enlargement revealed the same tendency, contrasting with the EU-15 one.

Conclusions Overall, the EU health status is improving, despite changes in its composition over the years. However, the average EU state of health declined with the 2004, 2007 and 2013 EU enlargements.

Keywords European Union · Health status · Public health · Burden of disease

Introduction

The idea of the European Union (EU) dates back to philosophers/visionaries such as Victor Hugo, who imagined a peaceful "United States of Europe" (Fontaine 2010). Although its initial goal was Franco-German peace and economic development, the goals are now more demanding, including security, economic and social solidarity and shared values (European Observatory on Health Systems and Policies 2004; Fontaine 2010; Greer et al. 2013).

In 1951, with the Treaty of Paris, the sustainable production of coal and steel was the reasoning behind the creation of the European Coal and Steel Community by six European countries (i.e. Belgium, the Federal Republic of Germany, France, Italy, Luxembourg and the Netherlands) (European Observatory on Health Systems and Policies 2004; Fontaine 2010). In 1957, the Treaty of Rome established the European Atomic Energy Community and the European Economic Community (Fontaine 2010). The first enlargement took place in 1973, with the accession of

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✉ João Vasco Santos
jvasco.santos@gmail.com

1 MEDCIDS – Department of Community Medicine, Information and Health Decision Sciences, Faculty of Medicine, University of Porto, Porto, Portugal

2 CINTESIS - Centre for Health Technology and Services Research, Porto, Portugal

3 Public Health Unit, ACES Grande Porto VIII – Espinho/Gaia, ARS Norte, Vila Nova de Gaia, Portugal

4 Department of Health Policy, London School of Economics and Political Science, Houghton Street, London, UK

5 Section of Hygiene, Institute of Public Health, Università Cattolica del Sacro Cuore, Fondazione Policlinico "A. Gemelli" IRCCS, Rome, Italy

Denmark, Ireland and the UK (European Observatory on Health Systems and Policies 2004; Fontaine 2010).

Due to a growing need for European integration, the Treaty of Maastricht established the European Union in 1992. Since then, the EU has implemented several public health policies and has provided a framework for actions on public health and prevention of diseases (Azzopardi-Muscat et al. 2017; Cucic 2000; European Observatory on Health Systems and Policies 2004). Although this provided the Union greater authority, Member States retained the exclusive responsibility for delivering health to their populations (Cucic 2000). Nevertheless, the EU maintains an indirect impact on health services in Member States, with important influence in activities such as health research, medical training, pharmaceuticals, medical technology, telematics or social security (Cucic 2000; Fontaine 2010).

Since 1992, the EU has been changing in size and nature, totalling 28 countries until 31 January 2020, when the United Kingdom withdrew from it. Before the EU enlargement to 25 countries, Avgerinos et al. (2004) alerted that, with the inclusion of such a diverse group of countries with considerable dissimilarity regarding health status, an EU common healthcare policy should be outlined. In addition, McKee and Nolte (2004) pointed out that the accession of those ten countries, with an average wealth the equivalent to half of that of the EU-15 countries and a population size that amounted to a 28% increase in EU population, would certainly impact health and health policy, to an uncertain extent. Specifically, issues such as bridging the health gap, addressing specific health problems and improving health systems performance assessment (HSPA) should be addressed (Avgerinos et al. 2004).

Although an HSPA instrument with common indicators and shared comparable data from Member States could be used as a way to evaluate health care at an EU level, contributing to the setting of health priorities, policymaking, greater transparency and cross-country comparisons, there is no European-wide coherent framework (Braithwaite et al. 2017; Franklin 2017; Peric et al. 2017). Effectiveness, as one of the main dimensions of HSPA, includes state of health assessment (Braithwaite et al. 2017; Smith et al. 2008), the indicators of which should be comparable, valid, comprehensive, transparent and standardized, reflecting population health and enabling better priority setting (Etches et al. 2006; Parrish 2010).

Although there are some recent reports on the EU state of health (OECD 2018; Santos et al. 2019) that have already addressed time trends, and there has been a debate on the health impact of the EU enlargements (European Observatory on Health Systems and Policies 2004), there are no studies analysing the EU state of health time trends, comparing different EU groups or measuring the impact of the enlargement on the average EU health status. Thus, our main goal was to analyse health status' time trends in the European Union between 1990 and 2017, comparing different EU groups' compositions, and to study how the entry of new countries in the EU has affected these time trends, by using an interrupted time-series analysis.

Methods

We performed a retrospective study using health and demographic estimates from the Global Burden of Disease (GBD) 2017 study to assess health status within EU countries.

The GBD 2017 study was a collaborative effort to measure health at global, regional, country and sub-country levels, quantifying the burden of more than 350 diseases and injuries and 84 risk factors between 1990 and 2017 for 195 countries. The GBD produces estimates of mortality, years of life lost due to premature mortality (YLLs), years lived with disability (YLDs), disability-adjusted life years (DALYs), life expectancy, healthy life expectancy (HALE), morbidity (both prevalence and incidence) and risk factors exposure (GBD 2017 Causes of Death Collaborators 2018; GBD 2017 DALYs and HALE Collaborators 2018; GBD 2017 Disease and Injury Incidence and Prevalence Collaborators 2018; GBD 2017 Mortality Collaborators 2018; GBD 2017 Risk Factor Collaborators 2018).

We extracted the number of deaths for all causes, YLLs, YLDs, DALYs, life expectancy, HALE and population estimates using the GBD results tool (GBD Results Tool), for all EU countries between 1990 and 2017, by year, country, age and sex. Sub-totals were then computed for EU groups, as defined by the number of Member States in the EU composition at different time periods (i.e. EU founders, EU-9, EU-10, EU-12, EU-15, EU-25, EU-27 and EU-28—groups' definitions are presented in Supplementary Table 1).

Information regarding mortality, used in the GBD study, comes from country-specific vital registration (VR) systems. Countries with complete VR systems permitted the development of the GBD model life table system standard, driven almost exclusively by the observed age pattern of mortality in those countries. Within the 28 EU countries between 1990 and 2016, all but Cyprus had complete VR final estimates (95% or more VR data complete) throughout the studied period. The YLLs—a measure of premature mortality—are computed by the sum of each death multiplied by the GBD standard life expectancy at each age. More detailed information on the methodology regarding the estimation of mortality and of YLL can be found in the GBD 2017 study (GBD 2017 Causes of Death Collaborators 2018; GBD 2017 Mortality Collaborators 2018).

Prevalence and incidence measures reflect all the accessible information on disease occurrence, natural history and severity documented over multiple sources (e.g. hospital inpatient or epidemiological surveillance databases), satisfying minimum quality standards. For each disease, the GBD study combines all data sources and applies the Bayesian meta-regression tool DisMod-MR 2.1 for data pooling and bias adjustments (Flaxman et al. 2015). The used disability weights are constructed based on the population surveys by Salomon et al. (2012, 2015). A total of 234 health states are considered, and YLDs are computed using these metrics. DALYs are calculated by the sum of YLLs and YLDs. More detailed information on the methodology regarding the prevalence, incidence and YLDs estimation can be found in the GBD 2013, 2015, 2016 and 2017 Disease and Injury Incidence and Prevalence studies (GBD 2015 Disease and Injury Incidence and Prevalence Collaborators 2016; GBD 2016 Disease and Injury Incidence and Prevalence Collaborators 2017; GBD 2017 Disease and Injury Incidence and Prevalence Collaborators 2018; Global Burden of Disease Study 2013 Collaborators 2015).

Based on demographic prediction and the GBD model life tables, life expectancies for each age group are calculated and life expectancies at birth were analysed. HALE, the number of years that a person lives with full health, is calculated based on estimates of the number of YLDs and multiple-decrement life tables using the method developed by Sullivan (1971). More detailed information on the methodology regarding the estimation of life expectancies and HALEs can be found in the GBD 2017 study (GBD 2017 DALYs and HALE Collaborators 2018; GBD 2017 Mortality Collaborators 2018). The proportion between HALE and life expectancy, i.e. the share of life spent (adjusted for) in good health, was calculated.

Adjusting for the age and sex effect, we performed a direct age–sex standardisation using the 2017 EU-28 estimated population, as standard, when applicable to the indicators considered—population, age–sex composition and weights/proportions are presented in Supplementary Table 2. Even though the GBD provides estimates of crude and age-standardized rates, we built our indicators from absolute numbers allowing the calculation for each EU group, the EU-28 and the former ones (the latter not provided by the GBD). Moreover, our approach not only allowed us to adjust rates using a standard population of our choice, but mainly allowed us to adjust for sex, which was not considered in the revision of the European Standard Population (European Commission 2013).

Annualized rates of change were calculated dividing the difference in the values in a given year and the baseline year by the latter and then divided by the difference in years between both (e.g. ($HALE_{2004}$–$HALE_{1990}$/$HALE_{1990}$)/(2004–1990) provides the corresponding annualized rate of HALE change based on data observed between 1990 and 2004).

In order to study the impact of the enlargement in the state of health of the EU, we have plotted time trends between 1990 and 2017 and performed an interrupted time-series analysis. For each EU enlargement, we performed the following model, considering the time period between the previous and following enlargements (between the closer enlargements):

$$\text{Health} = \beta 0 + \beta 1\,\text{time} + \beta 2\,\text{enlarged}_{\text{EU}} + \beta 3\,\text{time} * \text{enlarged}_{\text{EU}}.$$

The variable "$\text{enlarged}_{\text{EU}}$" is equal to 0 before the enlargement occurs and equal to 1 for observations on or after the enlargement process. The variable "$\text{time*enlarged}_{\text{EU}}$" measures the time units (years) following the enlargement. β2 represents the immediate effects of the enlargement, whereas β3 indicates the slope change in the health status, following the enlargement process.

We used Microsoft Excel v16.0 and R v3.4 (R Core Team 2013) for data processing and statistical analysis.

Results

In 1990, when the EU was comprised of 12 countries (EU-12 group), there were a total of 2.22 million deaths and 107.6 million DALYs. Crude and age–sex-standardized mortality rates were of 1011 and 1479 deaths per 100,000 inhabitants, respectively, while for DALY rates were of 31,061 and 37,018 DALYs per 100,000 inhabitants, respectively. Figures 1 and 2 display the time trends of both mortality and DALY rates, respectively, for each EU group, also highlighting the EU-28 value at a specific time.

The crude mortality rate decreased until 2006 for all EU groups (lowest value of the time series), while from 2006 onwards, there was an increase, even considering the continuous enlargement of the EU (Fig. 1). The age–sex-standardized mortality rate described a decreasing trend, despite the discontinuities of increase observed with the enlargement to EU-25, EU-27 and EU-28, as well as in 2015 (Fig. 1). The crude DALY rate showed a decrease, with some increases in 2002/2003 (in most EU groups), in 2014/2015 and in 2016/2017 (Fig. 2). The age–sex-standardized DALY rate mainly showed a decrease except between 2014 and 2015. It also increased with the enlargements to EU-25, EU-27 and EU-28. Annualized rates of change for all studied population health metrics are presented in Tables 1 and 2.

In 2017, when the EU was comprised of 28 countries (EU-28 group), there were a total of 5.20 million deaths and 149.3 million DALYs. Crude and age–sex-

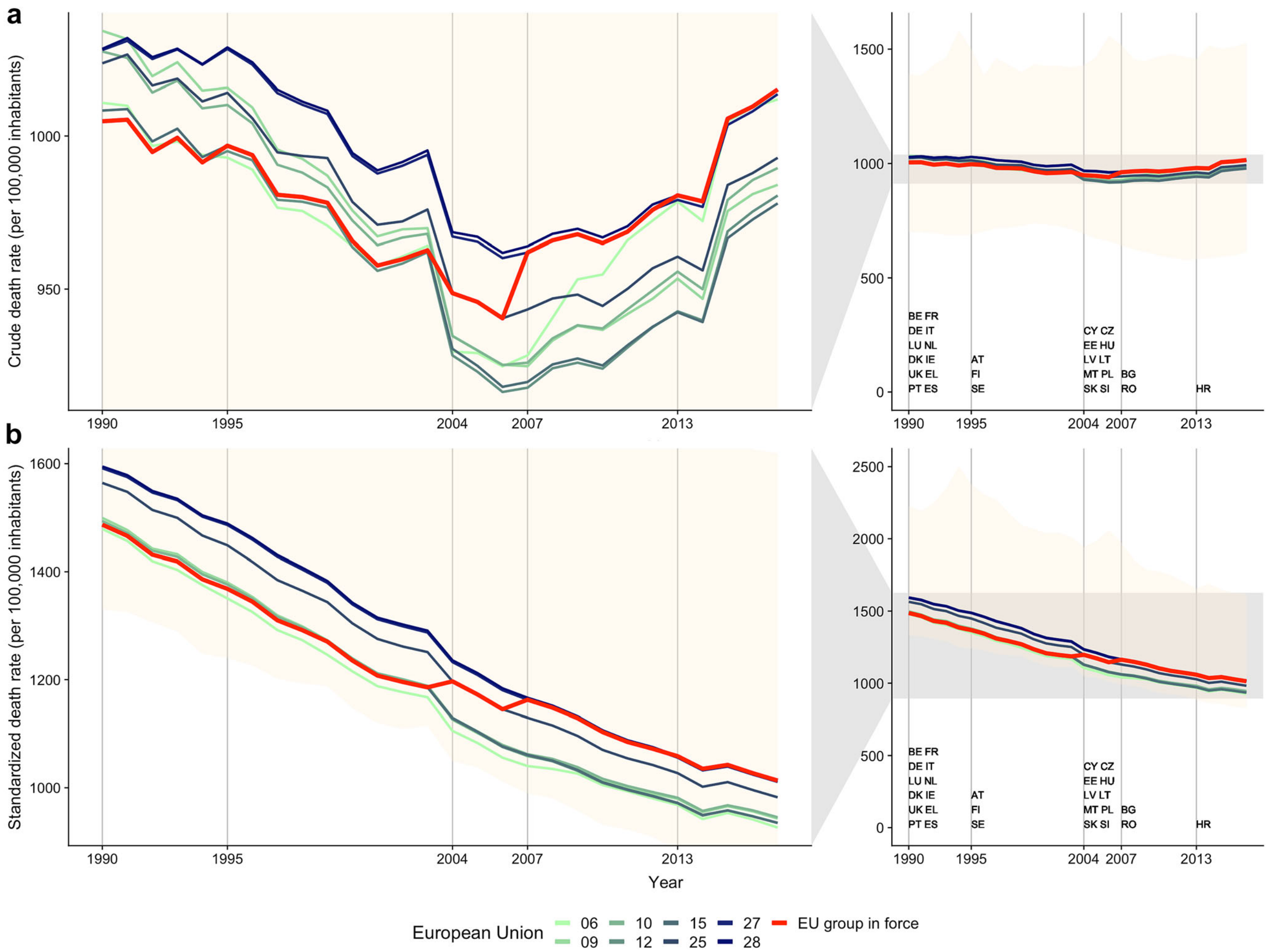

Fig. 1 Crude **(a)** and age–sex-standardized **(b)** rates (per 100,000 inhabitants) of mortality between 1990 and 2017 in European Union, by European Union group. In red are the lines of the EU groups in force in each year presented (color figure online)

standardized mortality rates were of 1015 and 1013 deaths per 100,000 inhabitants, respectively, while for DALY rates were of 29,135 and 29,082 DALYs per 100,000 inhabitants. The 2017 crude and age–sex-standardized mortality rates were lower when compared to the 1990 rates, considering each individual EU group, with the exception of EU-6 crude rate. When analysing the evolution of mortality rates throughout the changes of EU groups, we found that the EU-28 2017 crude mortality rate was the highest of the studied period, while the EU-28 1990 was the highest regarding age–sex-standardized rates (Fig. 1). EU-27 and EU-28 groups presented the highest age–sex-standardized death rate, followed by the EU-25 group (Fig. 1). Within each individual EU group, the 2017 DALY crude and age–sex-standardized rates were considerably lower than the 1990 rates (Fig. 2). The EU-27 and EU-28 groups had the highest age–sex-standardized DALY rates, followed closely by the EU-25 group (Fig. 2). Results for YLL and YLD are presented, respectively, in Supplementary Figure 1 and Supplementary Figure 2.

Life expectancy increased from 76.3 years in 1990 in the EU-12 group (75.1 years in the EU-28 group) to 80.9 years in 2017, in the EU-28 group (Table 2 and Fig. 3). The latter showed an annualized increase of 0.28%. HALE also increased, from 66.4 years in 1990 in the EU-12 group (65.1 years in the EU-28 group) to 69.7 years in 2017 within the EU-28 group (Table 2 and Fig. 3). The latter showed an annualized increase of 0.25%. Both indicators had a setback in the year 2015. HALE represented a proportion of near 87% of life expectancy. With the lower increase in HALE, in comparison with life expectancy, this proportion decreased slightly through the studied period (Table 2).

There was a gap between the EU-25, EU-27 and EU-28 groups and all the other groups, in both life expectancy and HALE. EU-27 and EU-28 groups were those with the lowest life expectancy and HALE throughout the studied time period, while the highest was the EU-6 group (Fig. 3).

Interrupted time-series analyses (Table 3) showed the value of discontinuity and slope changes of both crude and

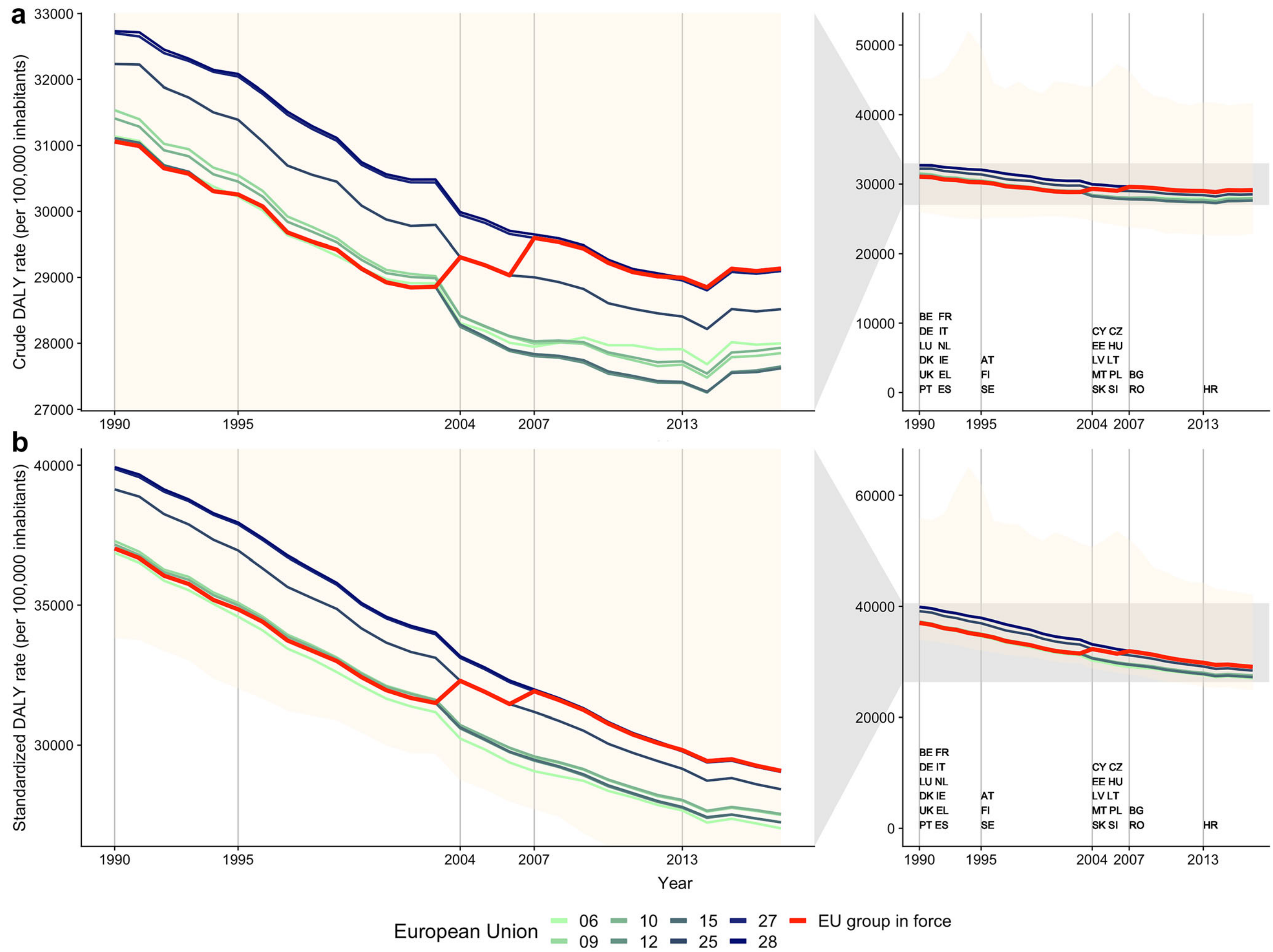

Fig. 2 Crude **(a)** and age–sex-standardized **(b)** rates (per 100,000 inhabitants) of disability-adjusted life years (DALYs) between 1990 and 2017 in European Union, by European Union group. In red are the lines of the EU groups in force in each year presented (color figure online)

age–sex-standardized rates, as well as for LE and HALE. While there were a statistically significant increase in those rates for the 2004 and 2007 enlargements and a non-statistically significant increase in the 2013 enlargement, the 1995 enlargement showed a non-statistically significant decrease for age–sex-standardized YLL and DALY rates. In LE and HALE, a similar pattern was observed (Table 3). A statistically significant difference in age–sex-standardized rates was also observed in the slope change in the 2013 EU enlargement.

Discussion

In this EU study, using estimates from the GBD 2017 study, we analysed time trends of health status indicators and the impact of the EU enlargements. All age–sex-standardized rates showed a decrease in 1990–2017, except between 2014 and 2015. YLD rates also decreased after 2000/2001 or 2005, depending on EU groups. Life expectancies showed the opposite trend. Thus, when adjusting for both age and sex, inhabitants from the EU are dying less, later and with less years lived with disability. In fact, this is translated into an increase in the life expectancy at birth of about 5.9 years and in healthy life expectancy of approximately 4.6 years (EU-28 group).

Regarding the EU enlargement, all age–sex-standardized rates and life expectancies worsened with the transition to EU-25 (in 2004), EU-27 (in 2007) and EU-28 (in 2013), while the 1995 enlargement showed the opposite effect for life expectancies as well as for age–sex-standardized YLL and DALY rates. The EU founders' group was the one that always presented the best health status' indicators.

Table 1 Annualized rate of change for crude and age–sex-standardized rates (per 100,000 inhabitants) of mortality, years of life lost (YLLs), years lived with disability (YLDs) and disability-adjusted life years (DALYs) between 1990 and 2017, in European Union and by EU group (only mortality rates were split into two periods as a clear trend change was found in 2006 crude rate)

	1990–2006		2006–2017	
	Mortality rate (%)	Age–sex-standardized mortality rate (%)	Mortality rate (%)	Age–sex-standardized mortality rate (%)
EU-6	− 0.53	− 1.79	0.86	− 1.12
EU-9	− 0.66	− 1.76	0.58	− 1.13
EU-10	− 0.62	− 1.73	0.63	− 1.13
EU-12	− 0.55	− 1.73	0.64	− 1.19
EU-15	− 0.56	− 1.72	0.59	− 1.20
EU-25	− 0.51	− 1.67	0.51	− 1.29
EU-27	− 0.41	− 1.61	0.51	− 1.31
EU-28	− 0.40	− 1.61	0.50	− 1.31

	1990–2017		1990–2017		1990–2017	
	YLLs rate (%)	Age–sex-standardized YLLs rate (%)	YLDs rate (%)	Age–sex-standardized YLDs rate (%)	DALYs rate (%)	Age–sex-standardized DALYs rate (%)
EU-6	− 0.87	− 1.54	0.35	− 0.05	− 0.37	− 0.99
EU-9	− 0.95	− 1.53	0.34	− 0.01	− 0.43	− 0.97
EU-10	− 0.92	− 1.52	0.35	− 0.01	− 0.41	− 0.96
EU-12	− 0.93	− 1.54	0.36	− 0.03	− 0.41	− 0.98
EU-15	− 0.94	− 1.54	0.36	− 0.03	− 0.42	− 0.98
EU-25	− 0.94	− 1.55	0.38	− 0.04	− 0.43	− 1.01
EU-27	− 0.91	− 1.52	0.39	− 0.06	− 0.41	− 1.01
EU-28	− 0.90	− 1.52	0.39	− 0.06	− 0.41	− 1.01

EU-6: Belgium, France, Italy, Luxembourg, the Netherlands and Germany; EU-9:EU-6, Denmark, Ireland and UK; EU-10:EU-9, Greece; EU-12:EU-10, Portugal and Spain; EU-15:EU-12, Austria, Finland and Sweden; EU-25:EU-15, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia; EU-27:EU-25, Bulgaria and Romania; EU-28:EU-27, Croatia

Time trends of EU health status

"Health at a Glance: Europe 2016" reported an increase in EU life expectancy at birth of 3 months per year, on average, possibly due to improved education, socio-economic conditions, lifestyle, more effective public health systems and healthcare achievements (OECD 2016; Mackenbach et al. 2013b). However, the more recent "Health at a Glance: Europe 2018" reported a decrease in life expectancy in 19 EU countries in 2015 related to a bad flu season and an increase in cardiovascular mortality in the winter months, which is reflected in our results (OECD 2018). In fact, this might be one of the reasons for the statistically significant slope change in the 2013 enlargement.

As stated in the "Health at a Glance: Europe 2016", the countries with the sharpest increase in life expectancy since 1990 were Estonia, Czech Republic, Lithuania and Bulgaria, i.e. all Central–Eastern European countries (OECD 2016). Central–Eastern European countries presented such an increase in life expectancy possibly due to cardiovascular mortality reduction, with the contributions of the opening of markets and subsequent access to healthy foods, medicines and improved health care, especially regarding hypertension (European Observatory on Health Systems and Policies 2004; Mackenbach et al. 2015; Zatonski 2007). It is known that a wide gap between Western and Central–Eastern Europe in terms of life expectancy exists (Boncz et al. 2014; European Observatory on Health Systems and Policies 2004; OECD 2016; Santos et al. 2019). In fact, this is reflected in our results, with EU-25, EU-27 and EU-28 having worse life expectancies than the other EU groups.

In terms of healthy life expectancy, the "Health at a Glance: Europe 2016" reported that there were virtually no gains for many EU countries between 2010 and 2014 (OECD 2016), though we found quite a constant increase in this period for different EU groups and an approximately 4.5-year increase throughout all periods. This might occur due to different concepts, methods and data sources for healthy life expectancy estimation. In fact, while Eurostat considers healthy life years as the number of years spent

Table 2 Life expectancy at birth (LE) and healthy life expectancy at birth (HALE) in 1990, years of accession of new countries and 2017, in European Union and by EU group

Life expectancy (years)	1990	1995	2004	2007	2013	2017	1990–2017 ARC (%)
EU-6	76.4	77.5	79.9	80.6	81.6	82.0	0.27
EU-9	76.3	77.3	79.7	80.4	81.4	81.7	0.27
EU-10	76.3	77.3	79.6	80.3	81.4	81.7	0.26
EU-12	**76.3**	77.3	79.7	80.4	81.5	81.9	0.27
EU-15	76.3	**77.3**	79.7	80.4	81.5	81.9	0.27
EU-25	75.4	76.4	**78.9**	79.5	80.8	81.3	0.29
EU-27	75.1	76.0	78.4	**79.2**	80.5	81.0	0.29
EU-28	75.1	75.9	78.4	79.1	**80.5**	**80.9**	0.29
HALE (years)	1990	1995	2004	2007	2013	2017	1990–2017 ARC
EU-6	66.5	67.4	69.3	69.8	70.5	70.8	0.24
EU-9	66.3	67.2	69.0	69.5	70.2	70.4	0.23
EU-10	66.3	67.2	68.9	69.5	70.2	70.4	0.23
EU-12	**66.4**	67.2	69.0	69.6	70.4	70.6	0.24
EU-15	66.4	**67.2**	69.0	69.5	70.3	70.6	0.24
EU-25	65.5	66.3	**68.3**	68.8	69.7	70.0	0.26
EU-27	65.2	66.0	67.9	**68.4**	69.4	69.7	0.26
EU-28	65.1	65.9	67.9	68.4	**69.4**	**69.7**	0.26
Proportion HALE/LE	1990	1995	2004	2007	2013	2017	
EU-6	87.0	87.0	86.7	86.6	86.4	86.3	
EU-9	86.9	86.9	86.6	86.4	86.3	86.2	
EU-10	86.9	86.9	86.6	86.4	86.3	86.2	
EU-12	**87.0**	86.9	86.6	86.5	86.3	86.3	
EU-15	86.9	**86.9**	86.6	86.5	86.3	86.2	
EU-25	86.8	86.8	**86.6**	86.4	86.2	86.1	
EU-27	86.8	86.8	86.6	**86.4**	86.2	86.1	
EU-28	86.8	86.8	86.6	86.4	**86.2**	**86.1**	

Annualized rates of change (ARC) between 1990 and 2017 are also presented for each EU group, as well as proportion of (HALE divided by LE). The corresponding expectancy for the EU group in force of each year is presented in bold

EU-6: Belgium, France, Italy, Luxembourg, the Netherlands and Germany; EU-9:EU-6, Denmark, Ireland and UK; EU-10:EU-9, Greece; EU-12:EU-10, Portugal and Spain; EU-15:EU-12, Austria, Finland and Sweden; EU-25:EU-15, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia; EU-27:EU-25, Bulgaria and Romania; EU-28:EU-27, Croatia

free of long-term activity limitation, i.e. disability-free life expectancy (OECD 2016), the GBD study considers it as the health-adjusted life expectancy (GBD 2017 DALYs and HALE Collaborators).

EU enlargement and impact on health status

The enlargement process, though complex, acts as a development engine for health protection policies (Guimarães and Freire 2007). It is a difficult process that needs to abide by the Copenhagen criteria (i.e. democracy, functioning market economy and the "acquis communautaire" (community acquis)—the EU rule of law). It allows the creation of an extended zone of peace and stability, the boost of economic growth and job creation, the increase in cultural diversity and the strengthening of the EU role in world affairs (European Observatory on Health Systems and Policies 2004). Concerns such as the process of harmonizing European and domestic legislation, the upward pressure on healthcare expenditure and pressure to improve population socio-economic status and health are linked to the EU accession (European Observatory on Health Systems and Policies 2004). On the other hand, the most important benefits might be the improvement in healthcare quality, the increasing focus on public health and the

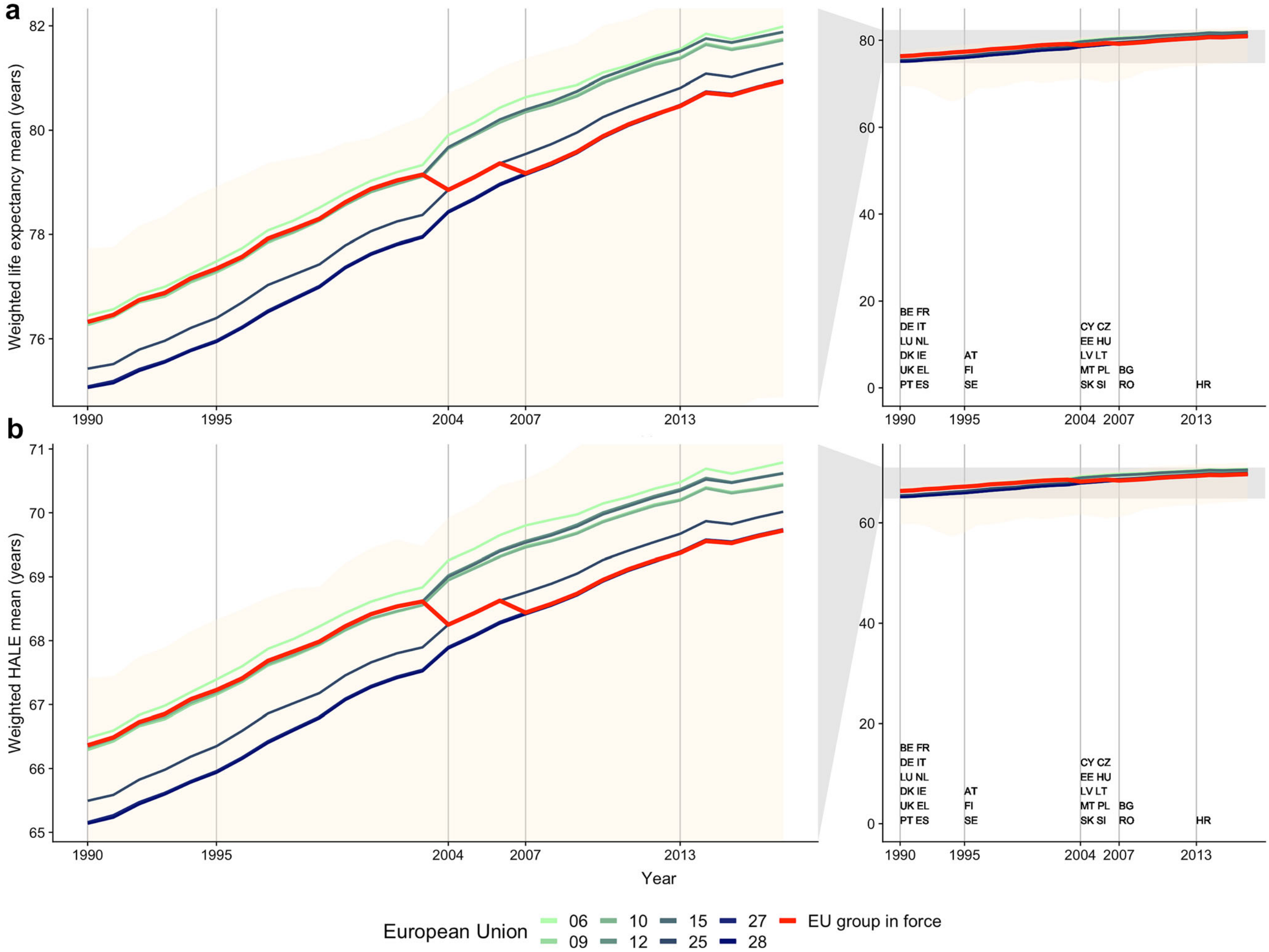

Fig. 3 Life expectancy (LE, in years)—**a** and healthy life expectancy (HALE)—**b** between 1990 and 2017 in European Union, by European Union group. In red are the lines of the EU groups in force in each year presented (color figure online)

strengthening of regulations and guidelines (European Observatory on Health Systems and Policies 2004).

For Romania and Bulgaria that have experienced a population decline, with an impoverished rural population and a large Roma community, their accession was full of opportunities for economic growth and healthcare improvement (McKee et al. 2007). However, different countries and different moments for the EU might mean different impacts or expectations (Avgerinos et al. 2004). In fact, we showed distinct impacts of enlargements, with the 1995 enlargement contrasting with the other studied enlargements. McKee and Nolte (2004) stated that any enlargement effects are likely to be gradual but substantial on the long-term and unpredictable, considering that health systems are influenced by the political and economic frameworks that surround them (Klazinga 2000). We aimed to study the immediate impact of enlargements on the average EU health status.

Other enlargements are also in discussion, namely for countries such as Iceland, Balkan countries or Turkey (Fontaine 2010; Kisa et al. 2007). In fact, population health may be one of the key issues of Turkish accession to the EU due to its considerably different health status (Kisa et al. 2007). Although we have focused on the EU enlargement process (until 2017), Brexit means a contraction of the EU. This will most likely impact health in the EU and in the UK, with expected effects ranging from negative to very negative (Fahy et al. 2017).

EU health policy and future trends

Avgerinos et al. (2004) pointed out the need for avoiding new "dividing lines" with the accession of countries lacking financial resources and with worse health indicators. One of the EU main goals is to reduce inequalities between Member States (e.g. it is the primary source of capital investment in healthcare infrastructure in poorer

Table 3 Coefficients and P-values of slope changes and discontinuity gaps from the discontinuity regression analyses regarding actual European Union health measures (crude and age–sex-standardized mortality, years of life lost (YLL), years lived with disability (YLD), disability-adjusted life years (DALY) rates, life expectancy and healthy life expectancy) for enlargement years

	Crude rate—coefficient (*P* value)				Age–sex-standardized rate—coefficient (*P* value)			
	1995	2004	2007	2013	1995	2004	2007	2013
Mortality								
Slope change	− 1.702	0.870	**5.399**	**7.886**	0.913	− 1.839	9.036	**9.209**
	(*0.312*)	(*0.804*)	**(0.007)**	**(0.007)**	(*0.736*)	(*0.756*)	(*0.169*)	**(0.005)**
Discontinuity gap	5.682	− 1.030	**25.278**	2.842	0.482	**49.497**	**53.810**	5.122
	(*0.342*)	(*0.856*)	**(< 0.001)**	(*0.670*)	(*0.960*)	**(< 0.001)**	**(0.008)**	(*0.481*)
YLL								
Slope change	− 13.572	35.690	35.440	**188.060**	− 0.771	12.390	82.420	**223.560**
	(*0.694*)	(*0.634*)	(*0.598*)	**(< 0.001)**	(*0.986*)	(*0.896*)	(*0.478*)	**(< 0.001)**
Discontinuity gap	− 3.522	**780.290**	**783.270**	60.550	− 50.998	**1294.240**	**1023.420**	83.030
	(*0.977*)	**(< 0.001)**	**(0.003)**	(*0.529*)	(*0.740*)	**(< 0.001)**	**(0.009)**	(*0.423*)
YLD								
Slope change	**20.294**	**13.303**	− 6.717	− **7.437**	**23.722**	6.040	**5.320**	− **7.054**
	(< 0.001)	**(0.077)**	(*0.650*)	**(< 0.001)**	**(< 0.001)**	(*0.489*)	**(0.038)**	**(< 0.001)**
Discontinuity gap	**26.169**	**48.211**	− 1.415	9.061	15.516	**188.045**	**53.147**	4.294
	(0.029)	**(0.002)**	(*0.966*)	(*0.058*)	(*0.251*)	**(< 0.001)**	**(< 0.001)**	(*0.136*)
DALY								
Slope change	6.722	49.000	28.720	**180.620**	22.950	18.430	87.740	**216.51**
	(*0.853*)	(*0.544*)	(*0.599*)	**(< 0.001)**	(*0.620*)	(*0.856*)	(*0.446*)	**(< 0.001)**
Discontinuity gap	22.647	**828.500**	**781.860**	69.610	− 35.480	**1482.290**	**1076.570**	87.330
	(*0.861*)	**(< 0.001)**	**(0.001)**	(*0.473*)	(*0.828*)	**(< 0.001)**	**(0.007)**	(*0.403*)
Life expectancy								
Slope change	0.024	0.021	− 0.053	− **0.129**				
	(*0.282*)	(*0.649*)	(*0.451*)	**(< 0.001)**				
Discontinuity gap	0.049	− **0.642**	− **0.569**	− 0.041				
	(*0.527*)	**(< 0.001)**	**(0.012)**	(*0.539*)				
HALE								
Slope change	− 0.0004	0.008	− 0.043	− **0.091**				
	(*0.982*)	(*0.837*)	(*0.409*)	**(< 0.001)**				
Discontinuity gap	0.030	− **0.643**	− **0.465**	− 0.033				
	(*0.643*)	**(< 0.001)**	**(0.007)**	(*0.497*)				

Statistically significant values are presented in bold. All *p* values are presented in italic

Member States) and its support might contribute to health improvements in new Member States, e.g. by means of institutional reforms (Fahy et al. 2017; Fontaine 2010; Greer et al. 2013; Mackenbach et al. 2013a; McKee 2005).

The EU is also facing several challenges such as an ageing population, migration, unequal distribution of health professionals, new technologies, increasing cost of health care and rise in non-communicable diseases and multi-morbidity (Azzopardi-Muscat et al. 2017; Franklin 2017; OECD 2016, 2018; Rechel et al. 2013). Thus, it is crucial to improve the performance and sustainability of the EU health systems (Franklin 2017). Despite its importance, one of the main challenges regarding EU support in health decision-making and policy actions in Member States is the fact that this is a slow and difficult process, one that requires consensus amongst all Member States, with the EU retaining a more regulatory, supportive and promoting role (Cucic 2000; Guimarães and Freire 2007; Greer 2014).

In fact, health policy is so high up in Member States' agendas that most governments do not want EU interference (Duncan 2002), depending mainly on themselves to implement policies (Franklin 2017; Guimarães and Freire 2007). Another challenge is the domestic politics of Member States: health policy usually requires a high level of compromise between political parties, with different agendas and goals (Duncan 2002).

Several scenarios for EU health systems have already been discussed, such as harmonization, deregulation or synchronization (Cucic 2000), but there are drawbacks and restrictions that have so far prevented their implementation. EU law can and does have a direct and indirect impact on health service provision, despite national efforts to retain healthcare control (Greer et al. 2013; Greer 2014; Duncan 2002). In fact, a more unified approach to external quality assurance of healthcare systems can be foreseen, given their systems convergence (Avgerinos et al. 2004; Klazinga 2000).

Improvement in the health status of a population will also have implications on countries' economies. In fact, non-communicable diseases alone result in the loss of 3.4 millions of potentially productive life years with a € 115 billion impact on the EU economy, with important economic losses of approximately 2% of gross domestic product (OECD 2016; Vandenberghe and Albrecht 2019). Health can contribute to economic performance in several ways, i.e. labour productivity, labour supply, education and savings/investment (Suhrcke et al. 2006). Moreover, health is a good investment not only as it is a capital good but also a consumption good, being an important component of global welfare and individual utility (Suhrcke et al. 2006; Mackenbach et al. 2011). In fact, it should not be a choice between health and economy, but rather choosing the way that can lead to a "mutually reinforced upward spiral" (McKee 2005). Further studies could also address economic factors and their relationship with these outcomes.

Limitations

Other health status indicators such as infant and amenable mortality or health systems outputs (i.e. volume of healthcare services) indicators could have been studied, but we decided not to include them (Peric et al. 2018). Also, and undoubtedly, the measurement of health depends on its definition, which is still in debate (Huber et al. 2011; Saracci 1997; Van-Spijk 2015; WHO 1992). Another limitation of this study is that the same disability weights are applied to all EU-28 countries. It also relies on the quality of data from death registries, which are compulsory in all EU countries (OECD 2018), and other databases collected in the EU. However, the GBD has collated a unique database of summary measures of health, calculating estimates with scientifically sound methods and several (and different type of) databases. Regarding the interrupted time-series analysis, we applied this method with few data points which might decrease its power (Bernal et al. 2017). We also did not adjust for other factors, such as the EU economic crisis; thus, we measured the crude differences in the EU state of health before and after enlargements.

Conclusion

Although the EU state of health improved between 1990 and 2017, some enlargements clearly decreased its average. In fact, 2004 and 2007 EU enlargements stand out, while the 1995 enlargement had the opposite effect. Despite this decline in the average health status associated with enlargements, inhabitants from the EU, regardless of the EU group considered, are dying less when adjusting for both age and sex, dying later and living less years with disability, i.e. YLD. This article also stresses the importance of comparing the comparable or, at least, stating which EU group is compared, as the EU founders state of health differs substantially from the EU-28 group.

Although the question raised by Etches et al. (2006), i.e. "Has the use of population health indicators improved the health of populations?", might remain, we are confident that this is in fact the case, possibly as the result of health indicators-based policies. Also, as pointed out by McKee and Nolte (2004), "enlargement brings challenges, but also opportunities" and independently from EU enlargements or contractions, as stated by Greer et al. (2013), "every stage offers opportunities to make the health of Europeans worse, or better".

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Compliance with ethical standards

Conflict of interest The author declares that they have no conflict of interest.

Ethical statement As we used secondary publicly available data sets, with complete anonymized data (gathered estimates), there was no need for an ethical statement.

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