

## ORIGINAL RESEARCH

# A ten-year comparative study of cardiovascular disease publications, health and socioeconomic indicators between European countries

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**Abstract**

The aim of this study was to investigate and compare gross domestic product (GDP) per capita, the number of physicians per one million inhabitants, the number of cardiovascular disease (CVD) publications, standardized death rate (SDR) from ischemic heart disease (IHD) and CVD per 100 000 inhabitants per year between European countries. GDP per capita from the Eurostat database served as the socioeconomic indicator, whereas human resources in medicine were reported as the number of physicians per million inhabitants. PubMed was searched for CVD publications published between 2005 and 2014 for each country. The rate per million inhabitants and proportions of CVD publications in the MEDLINE database were calculated. Results showed that although Croatia was the only country with stagnation in GDP per capita and with a lower rate of physicians than Austria ( $P = 0.007$ ) and the Czech Republic ( $P = 0.005$ ), Croatia had a lower SDR from IHD and CVD than the European region ( $P = 0.05$ ,  $P = 0.021$ ; respectively), and had a continuous decrease in the average annual growth rate of IHD and CVD (-2.36%, -3.81%; respectively). In conclusion our study showed that Croatia, despite being the only country with the stagnation of GDP per capita and a relatively low rate of physicians, had a SDR from IHD and CVD that was lower than in the European region which continuously decreased during the study period.

**Keywords**

Cardiovascular disease; Croatia; Gross domestic product; Publications; Health status indicators

## 1. Introduction

Cardiovascular disease (CVD) is the main cause of death in developed countries worldwide. It is an important cause of disability and a source of increased economic and social burden for society. The World Health Organization estimated that CVD led to 17.9 million deaths globally which is 31% of all deaths annually [1–3]. The ratio is even larger in Europe, where CVD is responsible for more than 4 million deaths or 46% of all deaths annually [4].

CVD is also a major contributor to inequalities in the health status of inhabitants in Europe. In comparison to Western Europe, Eastern Europe traditionally had a higher overall, and especially CVD related mortality, but considerable differences could be seen among individual Eastern European countries [5–7]. One of the reasons for the difference between countries in ischemic heart disease (IHD) and CVD mortality is the variance in the economic status of each country. An increase in the gross domestic product (GDP) per capita strongly correlates with a decrease in the IHD and CVD mortality [8].

The number of scientific publications published in a country is a good indicator of scientific development [9]. Every country has a different approach to science and investments in science, but wealthier countries generally tend to invest more in science than poorer countries. Economically more prosperous countries, with a larger GDP, create more opportunities for research and are scientifically more successful [10, 11]. In the period from 1991 to 2004, there were advances in cardiovascular medicine in Croatia that were not reflected in scientific productivity [12]. Also, a significant progress in the clinical practice, which was measured by an increase in the number of coronary angiograms by 8.5% and percutaneous interventions by 15%, has been recently reported [13]. Publications directly influence decisions made by physicians in their clinical practice [14]. Advancements in clinical practice are usually followed by an increase in clinical trials that ultimately result in increased scientific publications.

In order to explore country-specific differences in clinical practice related to cardiovascular medicine and scientific productivity, our primary goal was to determine the GDP per

capita, the number of physicians per one million inhabitants, standardized death rate (SDR) from IHD and CVD per 100 000 inhabitants per year in population in Croatia, and then to compare the same parameters for Slovenia, Hungary, the Czech Republic, Poland, the Slovak Republic and Austria between 2005 and 2014. Our secondary goal was to investigate whether progress in clinical practice in Croatia had been followed by an increase in the number of CVD publications.

## 2. Materials and methods

Lukenda *et al.* reported intriguing results in the period from 1991 until 2004 so we used similar methods for selected countries in our study to explore and update these findings [12]. We searched the MEDLINE database using PubMed to identify publications on CVD from 2005 to 2014 [15]. The term “cardiovascular disease” was entered as the Medical Subject Headings (MeSH) descriptor, and country names (Croatia, Slovenia, Hungary, Czech Republic, Slovak Republic, Poland, and Austria) were entered as the descriptor with (AD) abbreviation to obtain publications with the author’s affiliation from each of these countries. Dates from January 1 until December 31 were entered for every year between 2005 and 2014 in the “Publication date” field.

The number of CVD publications from each country was expressed as the publication rate (number of CVD publications per 1,000,000 inhabitants per year) and a proportion of CVD publications in the total number of publications from that particular country in the MEDLINE database.

Data on GDP per capita and population size on January 1 in the selected years were retrieved from the Eurostat database [16]. GDP per capita is expressed in thousands of euros per inhabitant per year. Human resources in medicine (number of physicians per 100,000 inhabitants per year) and the cardiovascular health indicators (SDR for both sexes aged 0-64 from IHD and CVD) for the 2005-2014 period for each country were obtained from the “European health for all database” [17]. This database allows the analysis of trends and international comparisons for a wide range of health indicators to support the formulation and monitoring of health policy at national and international levels. Data with the number of physicians for the Slovak Republic were available only for the year 2007 so this country was excluded from this particular analysis. Data for SDR from IHD and CVD for Slovenia were available in the same database from 2005 to 2010; data from 2011 to 2014 were obtained from the National Institute of Public Health of the Republic of Slovenia [18]. SDR is the age-standardized death rate calculated using the direct method and standard European population structure which has allowed an unbiased comparison between countries, serving as health indicators and providing estimates of the cardiovascular health of the population.

### 2.1 Statistical analysis

Data were entered into the electronic spreadsheet and statistical analysis was performed using the Statistica 10 software package (StatSoft Inc., Tulsa, OK, USA). To investigate possible differences in GDP per capita, the number of publications per

one million inhabitants per year, number of CVD publications, number of physicians, and the SDR from IHD and CVD between selected countries, we used the chi-square test with the Yates correction. For each parameter, the median of all values was calculated. In the chi-square test, the number of years above and below the median was entered for every country and the parameter of interest and used for comparison between each of the countries. If the value of any parameter in the year was identical to the value of the median, the value was placed above the median. Statistical significance was set at  $P < 0.05$ .

To compare temporal changes in GDP per capita, the number of publications per one million inhabitants per year, the number of CVD publications, number of physicians, and the SDR from IHD and CVD between the countries, we used the chain index. The chain index is the most widely used parameter in economic research which compares the value of the investigated parameter in the selected year with the value from the preceding year. The geometric mean of all chain indexes for each parameter from each country was used for calculation of the average annual growth rate. The geometric mean has been suggested as the most descriptive and reliable method for calculating average annual growth rate [19].

## 3. Results

Croatia had a significantly lower GDP per capita than the Czech Republic, Austria, Slovenia (chi-square = 16.22,  $P < 0.001$ ) and the Slovak Republic (chi-square = 4.26,  $P = 0.039$ ) (Table 1). Austria was the leading country for GDP per capita with an average of 35.4 thousand euros (Fig. 1). Croatia had a relatively constant GDP per capita of 10.2 thousand euros in 2005 and in 2014. Croatia had the lowest average annual growth rate of GDP per capita and it was the only country with a GDP stagnation (Table 2).

Austria had the greatest number of CVD publications per million inhabitants yearly with an average of 55.9 and the Slovak Republic had the least publications with the average of 8.1 (Fig. 2). Slovenia and Croatia had the lowest increase in the average annual growth rate in the number of CVD publications (2.21%, 6.18%; respectively) (Table 2).

No difference was observed in the number of CVD publications in the total number of publications between Croatia and other countries (Table 1). There was a decline in the average annual growth rate in the number of CVD publications in the total number of publications in most countries, except in the Czech Republic and Hungary (Table 2) (Fig. 3).

Croatia had a lower total number of physicians per one million inhabitants compared to Austria (chi-square = 7.912,  $P = 0.005$ ) and the Czech Republic (chi-square = 7.193,  $P = 0.007$ ) (Table 1). All countries had an increase in the average annual growth rate and Croatia, with 2.56%, had the highest (Fig. 4) (Table 2).

Croatia had a lower SDR from IHD than Hungary and the Slovak Republic (chi-square = 4.267,  $P = 0.039$ ) but it was higher than in Slovenia and Austria (chi-square = 4.267,  $P = 0.039$ ) (Table 1). Croatia had a borderline lower SDR from IHD than the European region (chi-square = 3.801,  $P = 0.05$ ). Poland had the greatest decrease of average annual growth rate from IHD (-5.04%) (Fig. 5) (Table 2).

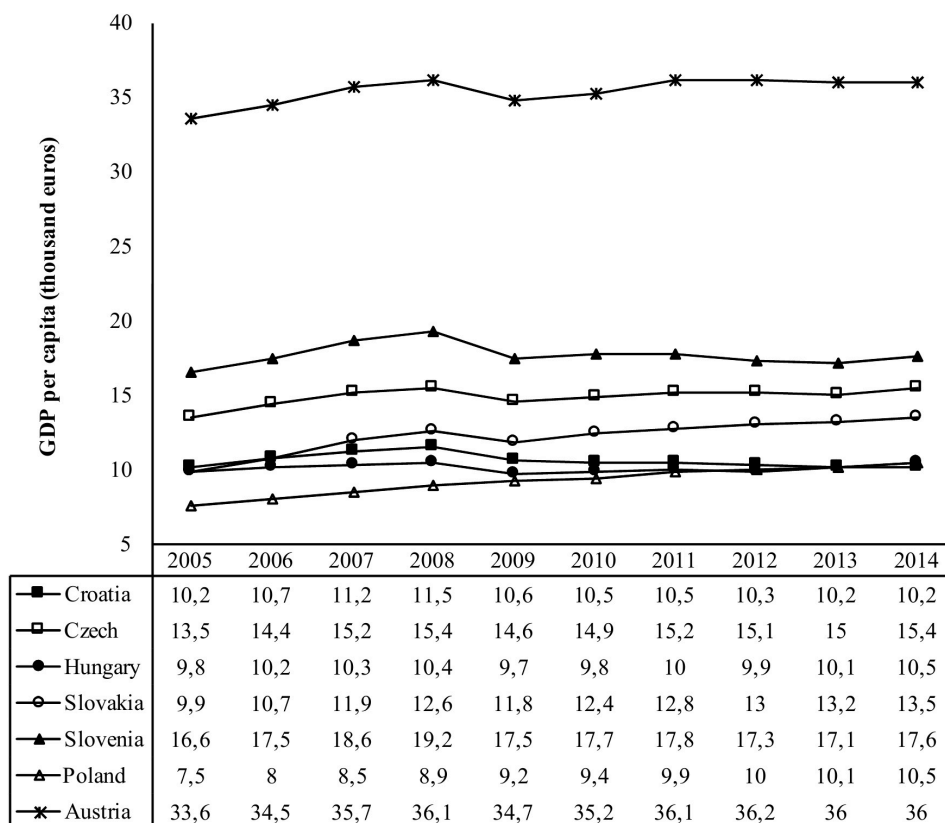


FIGURE 1. GDP per capita in euros in period between 2005 and 2014. Legend: GDP, gross domestic product.

TABLE 1. Calculated medians for investigated parameters and number of years above median for each country.

	GDP* per capita (thousand euros)	No. of CVD† publications/million inhabitants	% of CVD† publications in total number	No. of physicians/100 000 inhabitants	SDR‡ from IHD§/100 000 inhabitants	SDR‡ from CVD†/100 000 inhabitants
Median	12.5	20.5	8.2	295.8	31.5	71
Croatia	0 <sup>  ¶</sup>	6	4	3 <sup>**</sup>	5 <sup>††</sup>	4 <sup>‡‡</sup>
Czech Republic	10	6	2	9	3	1
Hungary	0	1	3	7	10	10
Slovenia	10	10	3	0	0	0
Slovak Republic	5	0	8	-	10	7
Poland	0	2	9	0	3	9
Austria	10	10	7	10	0	0
European Region	-	-	-	6	9	9

Legend: \* GDP, gross domestic product; † CVD, cardiovascular disease; ‡ SDR, standardized death rate; § IHD, ischemic heart disease; || P < 0.001 when compared to Czech Republic, Slovenia, Austria; ¶ P < 0.05 when compared to Slovak Republic; \*\* P < 0.05 when compared to Czech Republic and Austria; †† P < 0.05 when compared to Hungary, Slovak Republic, Slovenia, Austria; ‡‡ P < 0.05 when compared to Hungary and European Region.

Croatia had a lower SDR from CVD than Hungary (chi-square = 5.592, P = 0.015) and the European region (chi-square = 5.36, P = 0.021) (Table 1). Austria, with 30.5 per 100 000 inhabitants, had the lowest average SDR from CVD (Fig. 6). All countries had a decrease in the average annual growth rate from CVD; Slovenia had the greatest decrease (-5.77%) (Table 2).

#### 4. Discussion

To the best of our knowledge, this study is the first to investigate GDP per capita, number of CVD publications, number of physicians, SDR for IHD and CVD for Croatia compared to neighboring countries between 2005-2014.

CVD is the leading cause of morbidity and mortality globally [1, 4]. Several CVD risk factors, such as a higher BMI, systolic blood pressure, total cholesterol, as well as invest-

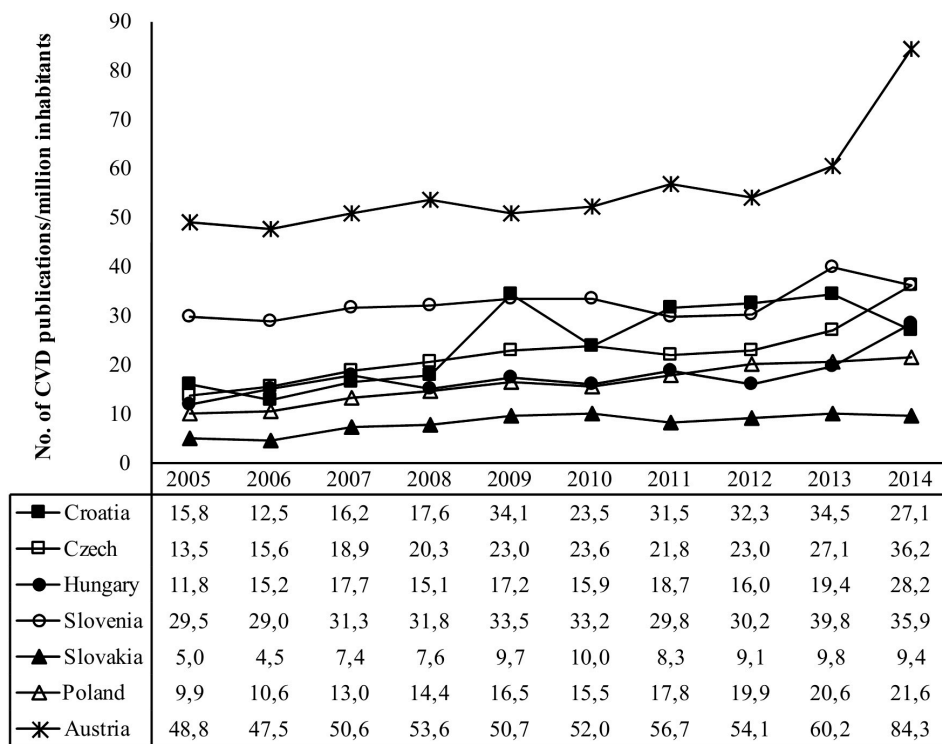


FIGURE 2. Number of CVD publications per million inhabitants per year. Legend: CVD, cardiovascular diseases.

TABLE 2. Average annual growth rate for each country between 2005 and 2014.

	GDP* per capita (thousand euros)	No. of CVD <sup>†</sup> pub- lications/million inhabitants	% of CVD <sup>†</sup> publications in total number	No. of physicians/100 000 inhabitants	SDR <sup>‡</sup> from IHD <sup>§</sup> /100 000 inhabitants	SDR <sup>‡</sup> from CVD <sup>†</sup> /100 000 inhabitants
Croatia	0.00	6.18	-0.72	2.56	-2.36	-3.81
Czech Republic	1.47	11.58	0.61	0.46	-3.06	-3.75
Hungary	0.77	10.16	2.16	2	-3.95	-3.58
Slovenia	0.65	2.21	-6.06	1.87	-2.42	-5.77
Slovak Republic	3.51	7.27	-2.86	-	-3.18	-4.36
Poland	3.81	9.06	-1.57	0.85	-5.04	-2.61
Austria	0.77	6.26	-3.08	1.75	-3.35	-3.15
European Region	-	-	-	1.49	-4.15	-3.99

Legend: \* GDP, gross domestic product; <sup>†</sup> CVD, cardiovascular disease; <sup>‡</sup> SDR, standardized death rate; <sup>§</sup> IHD, ischemic heart disease.

ments in health care, are directly associated with the GDP per capita [20–22]. Increased GDP per capita is directly associated with decreased IHD and CVD mortality [8, 23] probably via primary prevention of CVD risk factors. Countries with an annual increase in the GDP per capita have a more developed primary health care system which is associated with lower rates of CVD and all-cause mortality [24]. Croatia was the only country among those investigated with a stagnation in the GDP per capita. Surprisingly, the SDR from IHD and CVD was among the lowest, lower than the European region, which was associated with a continuous decrease during the study period. Similar results of lower CVD mortality were found in the Southern European countries when compared to Northern Europe [25]. There was an increase in the SDR from IHD worldwide in the period from 1990 until 2010. One of

possible explanations was the underuse of daily standard oral medications [26]. Our results showed that all the observed countries and the European region showed a decrease of SDR from IHD and CVD in the observed period.

Croatia, Poland, and Slovenia had fewer physicians compared to other countries. Recent studies suggest that the ratio of physicians per capita is a critical factor for SDR; i.e. the higher the ratio, the lower the SDR [27, 28]. In addition, a higher proportion of physicians and nurses is related to a higher quality of care and a lower incidence of adverse events [29].

Although Croatia was the only country among those investigated with a stagnation in the GDP per capita and had a relatively lower rate of physicians the SDR from IHD and CVD was lower than in the European region. The lower IHD and CVD mortality in Croatia could be partially due to the use of

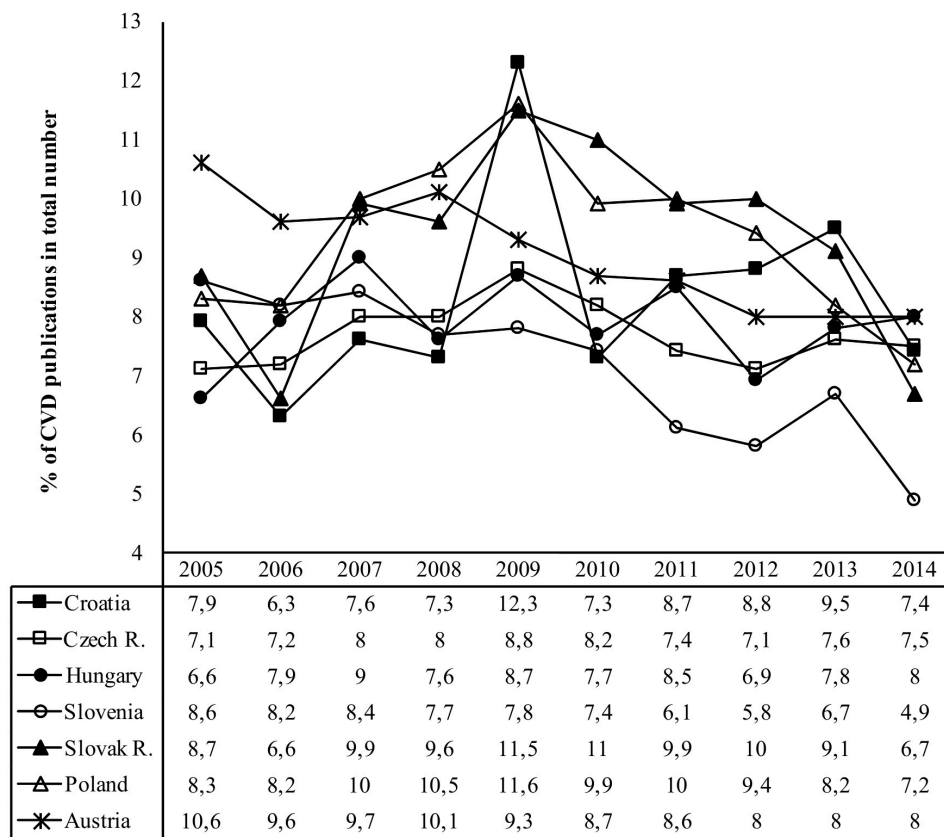


FIGURE 3. Percentage of CVD publications in overall MEDLINE database. Legend: CVD, cardiovascular disease.

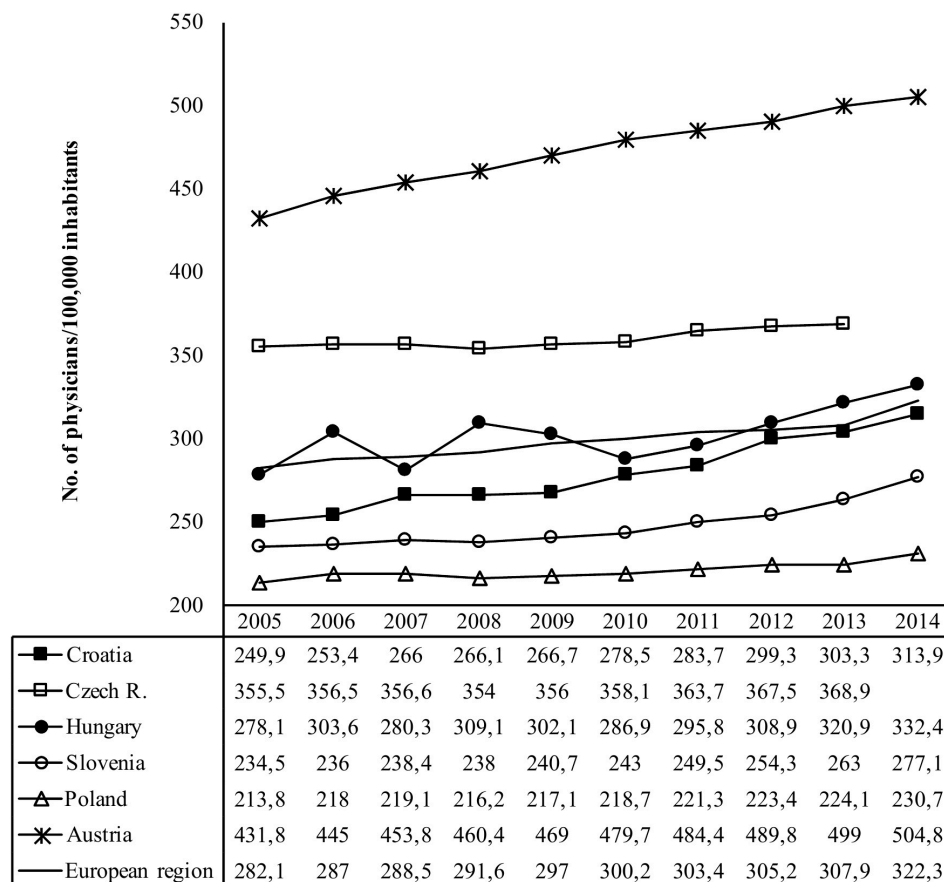
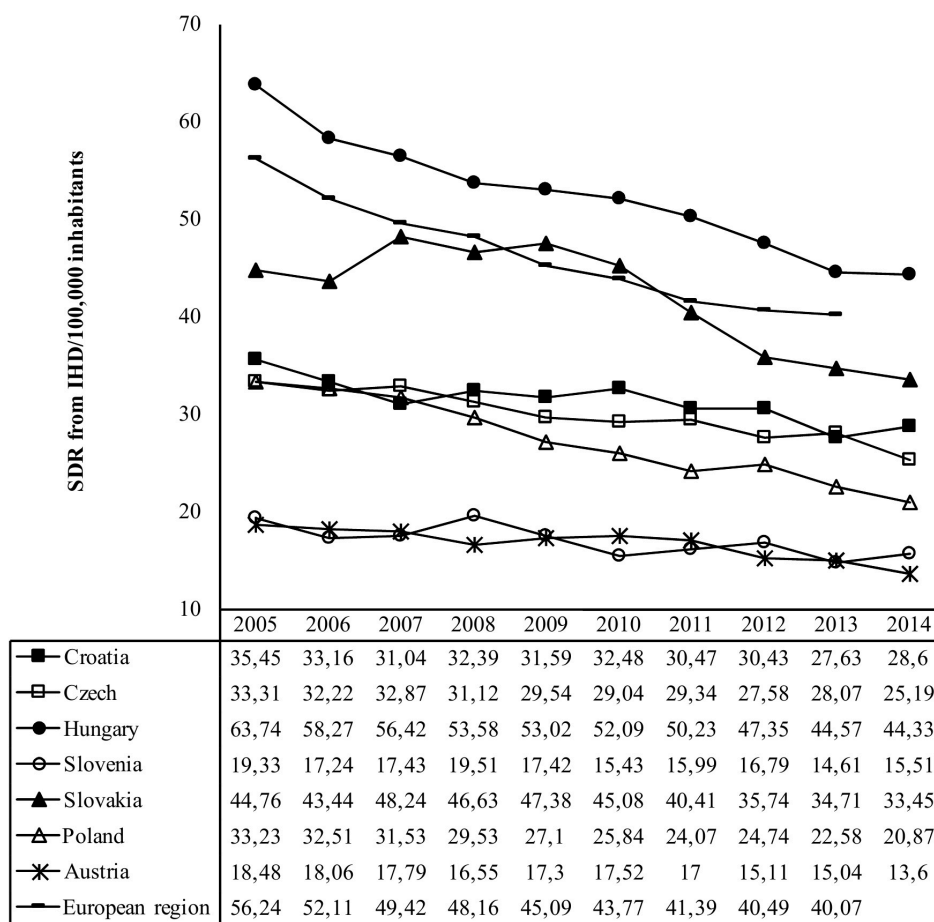


FIGURE 4. Number of physicians per 100 000 inhabitants per year.





**FIGURE 5. Standardized death rate from IHD per 100 000 inhabitants per year in population under age of 64 years.** Legend: IHD, ischemic heart disease; SDR, standardized death rate.

the Mediterranean diet which has been shown to have a CVD protective role [30, 31]. Also, the Mediterranean climate with its mild winters and summers could have a beneficial impact on overall health leading to a lower mortality [32]. Despite the stagnation in the GDP per capita, Croatia continuously advances and invests in primary prevention as per the European Society of Cardiology guidelines [33]. Recent studies suggest that the health care system in Croatia is very good despite the relatively low amount of investments when compared to Western European countries [34].

Our study found that scientific research in Croatia did not correlate with the progress in clinical practice in the period between 2005 and 2014. Croatia and Slovenia had the lowest increase in the average annual growth rate in CVD publications among all investigated countries. Lukenda *et al.* reported similar findings in which Croatia had the lowest rate of CVD publications in the period between 1991 and 2004 [12]. Recent studies suggest that Croatia has the lowest number of registered trials among countries from Central and Eastern Europe [35]. We suspect that the stagnation in the GDP per capita in Croatia has already affected the number of physicians and the average annual growth rate in CVD publications but not yet the SDR from IHD and CVD. Our assumption is that over a longer time period these factors would also be affected.

Our study had several limitations. First, data on the number of physicians for the Slovak Republic were lacking in the

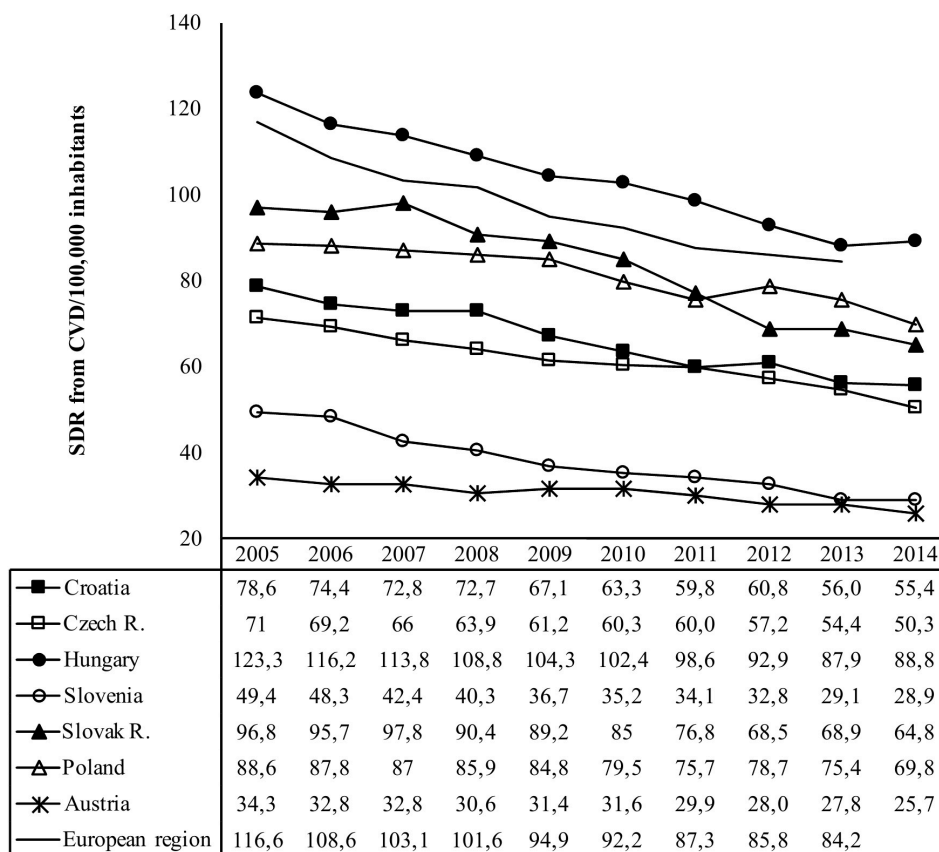
searched databases and were available only for 2007. Second, we evaluated cardiovascular scientific output only with the number of the CVD publications and with no evaluation of the quality of scientific publications.

## 5. Conclusions

We conclude that in Croatia, despite being the only country with stagnation of GDP per capita and a relatively low rate of physicians, SDR from IHD and CVD was lower than in the European region with a continuous decrease, possibly due to the Mediterranean diet and a mild climate. Cardiovascular scientific publications in Croatia did not follow the progress that was observed in clinical practice during this time period.

## AUTHOR CONTRIBUTIONS

Domagoj Markovic, Josip Lukenda and Viktor Culic designed the study. Domagoj Markovic, Visnja Kokic and Petra Simac collected the data. Domagoj Markovic and Piero Marin Zivkovic analyzed the data. Domagoj Markovic and Ingrid Prkacin analyzed the results and drafted the manuscript. Domagoj Markovic, Josip Lukenda, Viktor Culic, Visnja Kokic, Petra Simac, Piero Marin Zivkovic and Ingrid Prkacin read and approved the last version of the manuscript.



**FIGURE 6. Standardized death rate from CVD per 100 000 inhabitants per year in population under age of 64 years.**  
 Legend: CVD, cardiovascular disease; SDR, standardized death rate.

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**CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest regarding the publication of this article.

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