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Persistent geographical disparities in the use of primary percutaneous coronary intervention in 120 European regions: exploring the variation

Kristina G. Laut[1,2]*, MPH; Chris P. Gale[3,4], MD, PhD; Alma B. Pedersen[2], MD, PhD; Keith A. A. Fox[5], MD, PhD; Timothy L. Lash[2,6], DSc, MPH; Steen D. Kristensen[1], MD, DMSc

1. Department of Cardiology, Aarhus University Hospital, Skejby, Denmark; 2. Department of Clinical Epidemiology, Aarhus University Hospital, Denmark; 3. Centre for Epidemiology and Biostatistics, University of Leeds, Leeds, United Kingdom; 4. Department of Cardiology, York Teaching Hospital NHS Foundation Trust, York, United Kingdom; 5. Centre for Cardiovascular Science, University of Edinburgh, Edinburgh, United Kingdom; 6. Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, GA, USA

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KEYWORDS

- myocardial infarction
- primary percutaneous coronary intervention
- regional variation
- Western Europe

Abstract

Aims: Large inequalities in the use of primary percutaneous interventions (PPCI) for ST-elevation myocardial infarction (STEMI) are evident. In order to understand how we can help to implement best practice for STEMI patients, we investigated the variation in PPCI utilisation in 120 regions in 10 EU countries and the association with economic, organisational and demographic characteristics.

Methods and results: We performed an ecological study using mixed effects regression models in the following 10 countries: Austria, Belgium, Denmark, England and Wales, Germany, Italy, Portugal, Spain, Sweden, and Northern Ireland. The main finding was the annual number of PPCI per million inhabitants from 2003 through 2008. Overall, the annual increase in PPCI utilisation was 1.15 (95% CI: 1.12, 1.19) per million per year. Regional-level rates varied from 0.74 (95% CI: 0.42, 1.30) to 1.90 (95 % CI: 1.01, 3.55) per million per year. At a regional level, significant positive associations with PPCI utilisation were the number of physicians per 100,000 inhabitants; the number of nurses and midwives per 100,000 inhabitants; and the proportion of the region's population aged 50 to <70 years. At a country level, significant positive associations with utilisation were the year of STEMI treatment, population density per km^2; number of general hospital beds per 100,000 inhabitants; and the number of physicians per 100,000 inhabitants.

Conclusions: Between 2003 and 2008, PPCI utilisation increased significantly in the ten European countries studied, but there was a great variation within country regions. Regional variation in PPCI rates were associated with both demographic and supply factors, revealing substantial opportunities to improve PPCI utilisation across Europe at national and regional levels.

**Corresponding author: Department of Cardiology, Aarhus University Hospital Skejby, Brendstrupgaardsvej 100, DK-8200 Aarhus N, Denmark. E-mail: kristina@laut.dk*

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Introduction

Prompt reperfusion optimises outcomes of ST-elevation myocardial infarction (STEMI)[1,2]. Although programmes for delivering timely primary percutaneous coronary intervention (PPCI) in experienced centres have been implemented in some European countries, large inequalities in the use of PPCI for STEMI across Europe have been reported[3].

General research into healthcare inequality has focused on drivers for healthcare costs and attitudes towards implementation in groups of healthcare staff, and has often been restricted to a single country[4,5]. Patterns of PPCI utilisation in Europe according to economic, demographic and institutional context, and locality within countries have been sparsely examined. In order to understand how we can help to implement best practice for STEMI therapy, international comparative studies performed at a regional level in European countries may identify opportunities to reduce inequalities. Given the severity of STEMI, knowledge of factors hampering patient access to best evidence-based treatment would be the first step in reducing an unacceptable inequality with regard to life-saving treatment for STEMI patients in Europe.

Therefore, we conducted a study in order to: 1) quantify the variation in the use of PPCI among 120 regions in 10 European countries; 2) identify factors associated with such variation; and 3) investigate whether common factors associated with PPCI utilisation exist across regions, or whether these factors differ among regions. Our study therefore provides further insights into the factors affecting the implementation process of PPCI.

Methods

DESIGN AND SOURCE POPULATION

We conducted an ecological study of data aggregated on a regional level. The research was restricted to ten EU countries: Austria, Belgium, Denmark, England and Wales, Germany, Italy, Northern Ireland, Portugal, Spain, and Sweden.

DEPENDENT VARIABLE

We obtained regional data on numbers of PPCI procedures per one million inhabitants per year from 2003 to 2008 from national and international registries **(Online Table 1)**. PPCI was defined as the annual number of patients with a diagnosis of STEMI who underwent acute percutaneous coronary intervention (PCI). To be eligible for PPCI, patients had to meet the following criteria: symptom duration of ≤12 hours and ST-segment elevation ≥0.1 mV in at least two continuous leads (≥0.2 mV in V_1-V_3) or presumed new-onset left bundle branch block[6]. In countries where no national PCI registry existed (such as Germany), we received information on ICD-10 STEMI codes combined with the specific procedure codes for PCI. Data specifications and code numbers of STEMI according to the tenth revision of the International Classification of Diseases (ICD-10) are given in **Online Table 2**. Some countries were unable to provide data concerning PPCI frequency according to symptom duration (and therefore included patients undergoing PCI with a symptom duration of >12 hours) **(Online Table 1)**.

The regional analyses were based on the original country-specific area divisions. Regional data were available for 10 countries, comprising a total of 120 regions. England and Wales were grouped as a "country", although there are differences in care[7].

We selected 2003 as baseline because this was the year in which the European guidelines recommending PPCI as the first choice treatment for STEMI was introduced[8]. The guideline was revised for the first time in 2008, when we therefore censored our analyses[2,9]. Moreover, it was not possible to obtain valid data from the majority of regions after 2008.

EXPLANATORY VARIABLES

Data on the potential explanatory variables were obtained from Eurostat´s regional statistics **(Online Table 2)**[10]. Validated information on the explanatory variables from Eurostat was available for 2006[10]. We collected data on each region's demographics, supply factors, and healthcare system characteristics. Demographic data included age (proportion of the population in each age group), gender distribution and life expectancy of men and women. Supply factors included the number of physicians per 100,000 inhabitants, the number of nurses and midwives per 100,000 inhabitants, the percentage of the population with tertiary educational level according to the International Standard Classification of Education (ISCED) system group 5 & 6[11], gross domestic product (GDP) per capita (euros purchasing power parity), and the number of general hospital beds per 100,000 inhabitants. Information on the characteristics of each country´s healthcare system and remuneration schemes for hospitals and physicians in 2006 was available only at a national level, and therefore this information was excluded from the analysis. Regional data concerning the number of interventional or general cardiologists was not available; the number of medical physicians was used as a surrogate. In Northern Ireland the number of general hospital beds and educational level were available at a national level only: therefore, this single value was used for all the regions.

ANALYSIS

The annual change in utilisation of PPCI per region was modelled using linear regression. To investigate the effect of regional characteristics on regional differences in change in PPCI use, we performed the following analyses:

1. An overall analysis for all countries combined. We built an exploratory linear mixed-effects random slope and random intercept regression model (regions nested within countries, where covariates were included as grouped variables) using all available data **(Online Table 1)**. Life expectancy, sex distribution and educational level were not included in any of the models due to collinearity. The model was fitted via maximum likelihood.
2. Within country analyses. To quantify the relationship between the explanatory variables and changes in PPCI utilisation in England, Italy, Germany, Spain and Sweden we fitted a stepwise linear mixed-effects regression model with random intercepts for each region and a random slope for each explanatory variable **(Online Table 2)**. Inclusion of explanatory variables was informed by clinical and

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automated processes. Maximum likelihood estimation was used so that the null model could be calculated to compare statistically the addition of the predictor (p<0.05 suggested a better fitting model).

A natural log transformation was used to correct for right skewness of PPCI per one million inhabitants. All regression estimates are presented as antilogarithms along with their 95% confidence intervals (CI) and p-values, and therefore they represent the geometric mean change in PPCI use. All tests were two-sided, and a p-value <0.05 was used as a cut-off for statistical significance. All analyses were conducted using Stata Statistical Software: version 11.0 (Stata Corporation, College Station, TX, USA).

Results

TRENDS IN REGIONAL PPCI UTILISATION

Figure 1 depicts the regional rates of PPCI for STEMI per one million inhabitants for each country from 2003 to 2008. The rates varied substantially both by country and by region. Overall, rates of utilisation levels were highest in Germany and Austria and lowest in England, Northern Ireland and Spain **(Figure 1)**. The mean yearly change in PPCI utilisation was, however, largest in England and Wales with a growth of 1.29 (95% CI: 1.15, 1.43) per one million inhabitants per year from 2003 to 2008 whereas Germany had a stable level of utilisation (0.99 [95% CI: 0.94, 1.04]) **(Online Table 3)**.

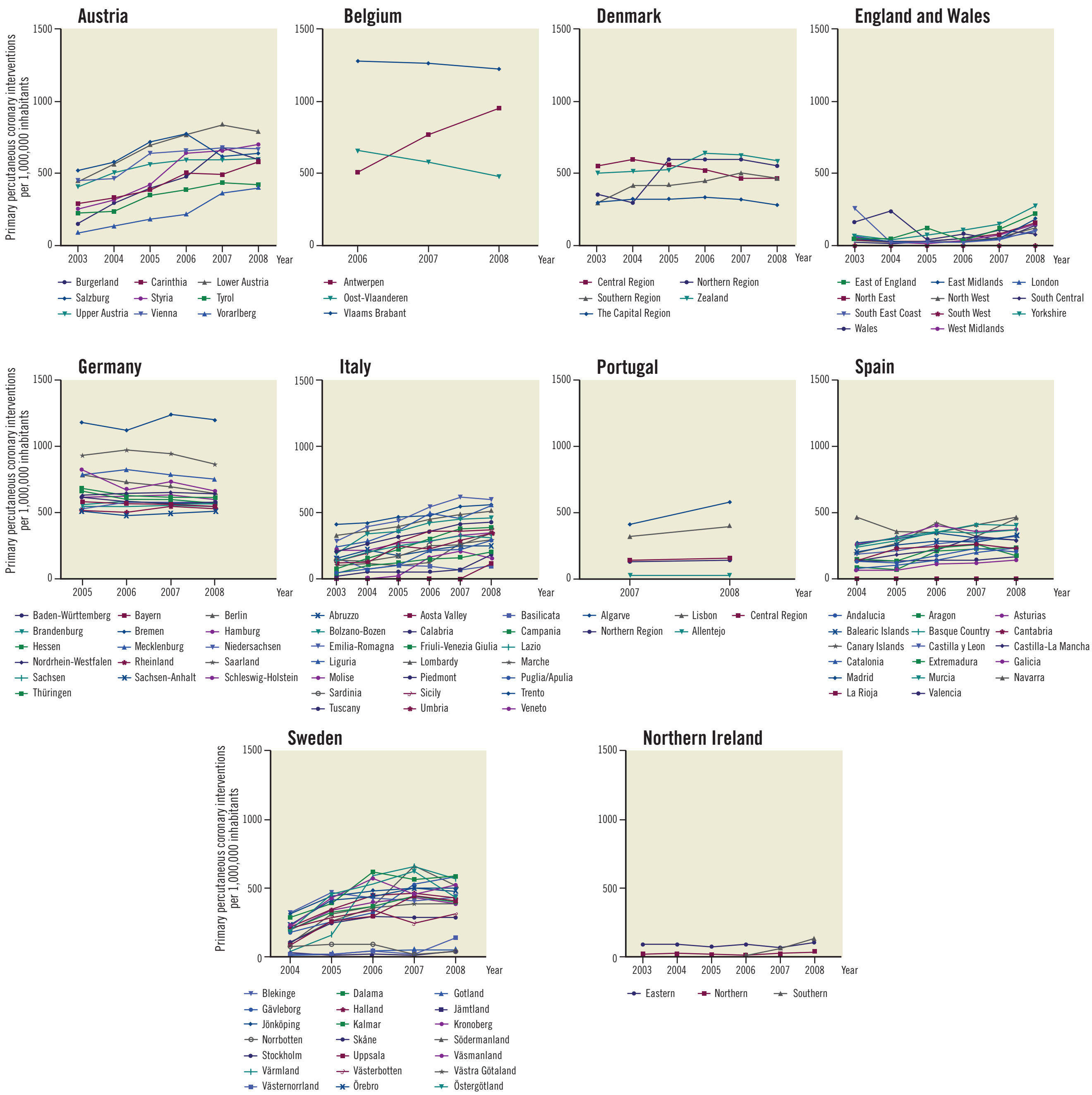

Figure 1. *Frequency of primary percutaneous interventions per one million inhabitants, by place of residence and year of treatment in 10 European countries, 2003-2008.*

The three countries with the largest regional inequalities were Italy, Spain and Sweden **(Figure 1)**. The annual regional change in PPCI utilisation per one million inhabitants varied in Sweden between a mean decline in utilisation of 0.74 (95% CI: 0.42, 1.30) per one million inhabitants (Norrbotten County) and a mean growth of 1.90 (95% CI: 1.01, 3.55) per one million inhabitants (Värmland County). In Germany and Denmark utilisation was stable over the years and the regions **(Figure 1, Online Table 3)**.

OVERALL FACTORS ASSOCIATED WITH CHANGES IN REGIONAL PPCI USE

Table 1 presents the multivariable analysis of the overall impact of the covariates on the change in regional use of PPCI over time. This revealed a significant positive association between PPCI utilisation and year of acute percutaneous revascularisation, the number of physicians per 100,000 inhabitants, the number of nurses and midwives per 100,000 inhabitants, and age distribution.

We observed a yearly growth in PPCI utilisation across all regions, with an overall mean growth of 1.15 per one million inhabitants per year (95% CI: 1.12, 1.19). Regions with >400 physicians per 100,000 inhabitants experienced a change in growth in PPCI utilisation of 1.75 (95% CI: 1.28, 2.39) per one million inhabitants compared with regions with <300 physicians per 100,000 inhabitants. The growth increased significantly with a higher underlying basis of physicians (p=0.01) **(Table 1)**. Regions with a number of nurses and midwives employed of >700 per 100,000 inhabitants experienced a growth in PPCI utilisation of 3.16 (95% CI: 1.75, 5.71) per one million inhabitants compared with regions with <300 nurses and midwives per 100,000 inhabitants. Likewise the growth increased significantly with a higher underlying basis of nurses and midwives (p<0.001) **(Table 1)**. Regions with a large proportion of people aged between 50 and <70 years experienced a faster growth in utilisation of PPCI (1.07 per one million inhabitants [95% CI: 1.01, 1.13]) **(Table 1)**.

Table 1. Possible factors associated with variation in utilisation of primary percutaneous coronary intervention (PPCI) per 1 million population in 120 regions in 10 European countries 2003–2008.

Covariate	Adjusted regression coefficient (95% CI)* Change in PPCI per 1,000,000	*p*-value, group level
Calendar year	1.15 (1.12,1.19)	<0.001
Physicians per 100,000 population		
<300	Reference	0.01
300-<400	1.23 (0.94, 1.60)	
400+	1.75 (1.28, 2.39)	
Number of nurses/midwives per 100,000 population		
<300	Reference	<0.001
300-<700	1.07 (0.69, 1.64)	
700+	3.16 (1.75, 5.71)	
Population density per km²		
<100	Reference	0.51
100-<400	1.11 (0.84, 1.47)	
400+	0.97 (0.63, 1.49)	
Age (years) percententage of population in each age group		
<30	1.02 (0.94, 1.10)	0.64
30-<50	1.02 (0.96, 1.09)	0.54
50-<70	1.07 (1.01, 1.13)	0.01
70+	0.94 (0.83, 1.06)	0.33
Numbers of general hospital beds per 100,000 population		
<350	Reference	0.34
350-<700	0.99 (0.69, 1.42)	
700+	0.80 (0.54, 1.17)	
GDP per capita in PPP EURO		
<25,000	Reference	0.67
25,000+	1.00 (0.79, 1.27)	

* Based on multivariable multilevel random slope and random intercept regression model. Variables are mutually adjusted

COUNTRY-SPECIFIC FACTORS ASSOCIATED WITH REGIONAL PPCI UTILISATION

Table 2 presents the country-specific multivariate analyses.

ENGLAND AND WALES

In England and Wales, PPCI utilisation was positively associated with the year of acute revascularisation **(Table 2)**. Overall, the mean annual growth in PPCI utilisation was 1.27 per one million inhabitants (95% CI: 1.13, 1.42) per year. Six regions (75.0%) demonstrated a significant increase in PPCI utilisation, with a highest mean change of 1.47 (95% CI: 1.06, 2.04) **(Online Table 3)** per one million inhabitants. There was a negative association between change in PPCI utilisation and the number of physicians (0.55 per 100,000 [95% CI: 0.31, 0.99]).

GERMANY

In Germany there was no mean change in PPCI utilisation (0.99 per one million inhabitants [95% CI: 0.97, 1.00]). The highest mean regional PPCI utilisation was 1.02 (95% CI: 0.95, 1.09) **(Online Table 3)**.

Regions in Germany with >400 population density per km² experienced a yearly growth in PPCI utilisation per one million inhabitants of 1.80 per 100,000 (95% CI: 1.48, 2.19) compared with regions with <100 population per km². Regions with a GDP per capita of 25,000+ euros experienced smaller growth compared with regions with GDP per capita of <25,000 euros (0.74 per 100,000 [95% CI: 0.60, 0.92]) **(Table 2)**.

ITALY

In Italy we found a positive association between the year of acute revascularisation and PPCI utilisation per one million inhabitants (1.21 [95% CI: 1.14, 1.28]) **(Table 2)**. Seventeen regions (81%) demonstrated a significant increase in PPCI utilisation with a highest mean regional utilisation of 1.89 (95% CI: 0.37, 9.72) **(Online Table 3)**. Regions with 350 to <700 hospital beds per 100,000 inhabitants (1.56 per 100,000 [95% CI: 1.03, 2.37]) experienced a greater yearly growth compared with regions with <350 beds per 100,000 inhabitants **(Table 2)**.

SPAIN

In Spain we found a significant association between the year of acute revascularisation and the utilisation of PPCI per one million inhabitants (1.15 per 100,000 [95% CI: 1.10, 1.20]). Seven regions

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(41%) demonstrated a significant increase in PPCI utilisation with a highest mean regional PPCI utilisation of 1.32 (95% CI: 1.24, 1.41) **(Online Table 3)**. Regions with 300 to <400 physicians per 100,000 inhabitants had an increase in PPCI utilisation of 1.45 per 100,000 (95% CI: 1.02, 2.06) procedures per one million inhabitants compared with regions with <300 physicians per 100,000 inhabitants. The growth was associated with a higher underlying number of physicians ($p>0.01$) **(Table 2)**.

SWEDEN

In Sweden, the year of acute revascularisation was associated with growth in PPCI utilisation (1.26 per 100,000 [95% CI: 1.15, 1.37]) **(Table 2)**. Four regions (19%) demonstrated a significant increase in PPCI utilisation with a highest mean regional utilisation of 1.90 (95% CI: 1.01, 3.55) **(Online Table 3)**.

Discussion

In this study, based on regional-level data from 10 European countries, we found that PPCI for STEMI became more frequent in all countries between 2003 and 2008; however, the same was not evident within all regions of these countries. From the time when PPCI was recommended in European guidelines, we found that countries and regions differed substantially in the time and rates of utilisation of PPCI. Notably, regional variation among countries remained. Three patterns of change in PPCI uptake over time were evident. One pattern, evident in Germany and Denmark, involved an early start and a steady level. Austria, Italy and Sweden illustrated a second pattern: later start, relatively fast growth. The third pattern is illustrated by England and Northern Ireland with a late start and a rapid growth. Later initial adoption appears to be the primary reason why PPCI rates in England and Northern Ireland differed from the other countries.

Previous studies of international differences in implementation of intensive treatment show similar patterns, but studies on inter-regional differences in implementation are uncommon[11-13].

These variations may have been influenced by the underlying demand for PPCI, expressed as the incidence of STEMI. The incidence and mortality from STEMI are not continuously monitored by surveillance registries, and few countries have valid regional data[5,14]. However, in recent years decline in the incidence of STEMI as well as decline in mortality in some countries has been evident. It is estimated that this decline is attributable to a reduction in risk factors and better preventive treatment, which may explain a reduction of PPCI utilisation in some countries (e.g., Denmark and Germany) towards the end of the study period[1]. However, comparing trends over time, as

Table 2. Country-specific factors possible explaining regional variation in growth in primary percutaneous coronary interventions, 2003-2008.

Covariate	Adjusted regression coefficient Change in PPCI per 1,000,000 (95% CI)*				
Country	England & Wales§	Germany**	Italy	Spain	Sweden#
Time	1.27 (1.13, 1.42)	0.99 (0.97, 1.00)	1.21 (1.14, 1.28)	1.15 (1.10, 1.20)	1.26 (1.15, 1.37)
Population density per km^2					
<100	–	Reference	Reference	–	Reference
100-<400	–	0.91 (0.78, 1.05)	1.32 (0.81, 2.16)	–	1.70 (0.26, 11.10)
400+	–	1.80 (1.48, 2.19)	1.31 (0.66, 2.58)	–	–
GDP per capita in PPP EURO	–			–	
<25,000	–	–	–	–	Reference
25,000+	–	0.74 (0.60, 0.92)	–	–	1.19 (0.58, 2.43)
Percent of population with highest educational level (ISCED index 5-6)					
<15	–	Reference	–	–	–
15-<25	–	1.82 (1.34, 2.47)	–	–	–
+25	–	1.54 (1.07, 2.20)	–	–	–
Physicians per 100,000 population					
<300	Reference	–	Reference	Reference	Reference
300-<400	0.55 (0.31, 0.99)	–	1.14 (0.68, 1.92)	1.45 (1.02, 2.06)	0.59 (0.12, 2.86)
400+	–	–	1.43 (0.88, 2.34)	2.19 (1.61, 2.98)	0.39 (0.15, 1.01)
Numbers of general hospital beds per 100,000 population					
<350	–	_	Reference	–	Reference
350-<700	–	Reference	1.56 (1.03, 2.37)	–	1.49 (0.06, 40.19)
700+	–	1.60 (1.37, 1.88)	–	–	–

*Based on two-level random intercept model of patients within regions within countries, with random slopes whereby variables are mutually adjusted. **Germany had only one physician and nurse category, therefore we were not able to include this in the country-level analysis. #Sweden had only one nurse category, only information on age in Stockholm, and no information on educational level. Therefore we excluded these variables in the country-level analysis. §England & Wales had only one nurse category and no information on number of general beds. Therefore we excluded these variables in the country-level analysis.

in this study, rather than point-in-time differences allows us to "factor out" some of the genetic, demographic and other influences on treatments of diseases across regions. These underlying factors are unlikely to change nearly as rapidly as medical practices. We do not believe, therefore, that differences in disease burden in western European countries fully explain our findings[12].

Providing access to PPCI has prompted many European countries to establish regional networks involving pre-hospital services, community hospitals and PCI centres[15,16]. Our study was not designed to capture the existence of such networks or any cross-border trafficking due to them, which might explain the low PPCI activity in some regions.

COMMON FACTORS ASSOCIATED WITH REGIONAL VARIATION IN PPCI UTILISATION

From our combined analysis it appears that supply factors (healthcare professional workforce) are an important determinant of PPCI utilisation. Also, previous studies suggest that supply-side characteristics have a strong influence on treatment patterns. These studies found that, in particular, the regulation of specialist capacity to perform medical procedures, as well as the availability of catheterisation laboratories ("supplier-induced demand"), is a strong determinant of technology use[11,13,17]. However, disagreement exists as to whether this association is based on the fact that physicians relocate to regions where supply is high or based on an already existing high demand[18-20]. Our study did not have access to information on the number of existing catheterisation laboratories, which might explain part of the detected regional variation[17].

Age and gender distribution may also be an important factor in healthcare utilisation. We found a significant association between the proportion of the population aged 50 to 70 years and growth in PPCI utilisation. This may be an expression of the regional demand for STEMI treatment in the region.

CONTEXT-SPECIFIC FACTORS

Factors explaining regional variation in PPCI use varied among countries, suggesting that implementation is complex. Our results support the literature in favour of context-specific implementation strategies that match the structures and needs of the society (region) in which they are to be implemented[11,21]. The need for context-specific implementation programmes within the field of PPCI were acknowledged in 2009 with the launch of the "Stent for Life Initiative"[22]. Preliminary reports from this initiative suggest a substantial increase in the number of PPCI cases performed[23].

Apart from Germany, we found a positive correlation between the year of STEMI treatment and regional growth in PPCI utilisation. This meets our expectations that some natural increase in utilisation will happen as the technology matures and healthcare workers are trained. Not all of the other parameters estimated in the country-specific analyses are intuitive, and might be partly explained by the fragility of the models. For example, in Germany GDP was negatively associated with PPCI use, conflicting with earlier research on factors associated with technology implementation[11,13,24]. An unmeasured factor, such as the construction of new central government supported hospitals in poorer regions, may explain this[25]. Notably, collinearity between GDP and the number of physicians cannot be excluded and the determinants of the association should be considered in future studies.

In England and Sweden we found negative associations between the number of physicians and the change in PPCI utilisation. In England specialist care provided by a consultant cardiologist is associated with improved outcomes[26], and it is likely therefore that the use of physicians (combined) as a surrogate marker for cardiology care was not appropriate in this instance. Some studies report an uneven distribution of physicians between rural and urban areas. Our aggregate figures might conceal large regional differences in physician distribution that could help explain these conflicting results. Future work should consider models in which implementation of PPCI is evaluated based on information at the patient level[18,20,27,28].

STRENGTHS AND LIMITATIONS OF THE STUDY

A unique advantage of our study was that it incorporated an international gathering of regional-level data concerning PPCI utilisation. Many variables are important in the diffusion of technology: here we uncovered both overall (inter-regional) and context-specific (intra-regional) factors associated with geographical variations in PPCI utilisation in Europe. STEMI is a common and well-defined clinical condition, allowing a good platform for international comparisons of diagnoses and treatment. Uniform definitions of the explanatory variables were available through Eurostat, a reliable source of aggregated population-based data on demographics, social conditions, and economy. Moreover, macro-level studies allowed both demand and supply factors to be explored, which in earlier studies have been shown to have a significant impact on technology implementation.

However, our study has limitations. Our data are on an aggregate level, which prevented the inclusion of patient-level characteristics, and therefore our results might not apply to all individuals in the underlying population. There were differences among countries in aspects of the data collection of PPCI utilisation in STEMI patients, which might affect the size of the reported inequality in PPCI use. Incomplete or non-compulsory reporting from hospitals may bias the factual size of inequality, but the size and direction of bias is unknown. Moreover, inclusion of patients receiving PCI >12 hours from symptom debut in some countries may have led to an overestimation of PPCI use **(Online Table 1)**. According to the available registries, these procedures comprise over 20% of the PPCI procedures per year (Italy and Berlin, Germany). Moreover, not all countries were able to provide data for five years. We used the ICD-10 coding system to obtain a comparable data registration of the STEMI diagnosis, which is well known worldwide. While some misclassification of the STEMI diagnosis cannot be ruled out, we do not expect the misclassification rates to vary over the time period of the study. Thus, potential misclassification does not explain the observed trends or the predictive variables of these trends. The study is based on registry data, which makes access to up-to-date data difficult due to the time for hospital reporting and validation of data. When initiating the study, we were not able to obtain valid data on PPCI utilisation from the majority of the countries after 2008. This will most likely underestimate the current level of use in all participating countries and regions. Our regional-level data models were based on an incomplete number of available variables, e.g., we had no access to data on the number and location of catheterisation laboratories. Finally, explanatory variables were registered for the year 2006, yet we modelled PPCI use from 2003 to 2008. Although interactions between time and the explanatory variables have been reported[25], we have no reason to believe that the underlying explanatory factors have changed substantially during the relatively short observational period of our study.

Implications and conclusions

With these caveats in mind, our findings offer some important contributions for research and clinical care. Our study is the first to examine regional-level variation across a large sample of countries over five years, thus providing a unique investigation of the variation in utilisation of PPCI. The study should be interpreted as a preliminary step in mapping PPCI practice across Europe. Our findings highlight the complexity of the factors that have a role in ensuring access to care. The implementation of PPCI takes place on many different levels and seems to differ from country to country. For this reason, interventions focused at several levels would most likely hasten PPCI uptake in the communities. Further studies accessing micro-level European data are needed and thus the development of high-quality databases at both national and international level is a prerequisite.

In conclusion, we found that the rate and level of PPCI implementation varied substantially among regions and countries across Europe. In the case of overall regional variation, this could partly be explained by both regional supply factors, such as the number of physicians, and demand factors, such as age distribution.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

References

1. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. *Lancet.* 2003;361:13-20.

2. Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC), Steg PG, James SK, Atar D, Badano LP, Blömstrom-Lundqvist C, Borger MA, Di Mario C, Dickstein K, Ducrocq G, Fernandez-Aviles F, Gershlick AH, Giannuzzi P, Halvorsen S, Huber K, Juni P, Kastrati A, Knuuti J, Lenzen MJ, Mahaffey KW, Valgimigli M, van't Hof A, Widimsky P, Zahger D. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Eur Heart J.* 2012;33:2569-619.

3. Widimsky P, Wijns W, Fajadet J, de Belder M, Knot J, Aaberge L, Andrikopoulos G, Baz JA, Betriu A, Claeys M, Danchin N, Djambazov S, Erne P, Hartikainen J, Huber K, Kala P, Klinceva M, Kristensen SD, Ludman P, Ferre JM, Merkely B, Milicic D, Morais J, Noc M, Opolski G, Ostojic M, Radovanovic D, De Servi S, Stenestrand U, Studencan M, Tubaro M, Vasiljevic Z, Weidinger F, Witkowski A, Zeymer U. Reperfusion therapy for ST elevation acute myocardial infarction in Europe: description of the current situation in 30 countries. *Eur Heart J.* 2010;31:943-57.

4. Phillips KA, Morrison KR, Andersen R, Aday LA. Understanding the context of healthcare utilization: assessing environmental and provider-related variables in the behavioral model of utilization. *Health Serv Res.* 1998;33:571-96.

5. Laut KG, Pedersen AB, Lash TL, Kristensen SD. Barriers to implementation of primary percutaneous coronary intervention in Europe. *European Cardiology.* 2011;7:108-12.

6. Thygesen K, Alpert JS, White HD. Universal definition of myocardial infarction. *Eur Heart J.* 2007;28:2525-38.

7. Gavalov L, on behalf of the Myocardial Ischaemic National Audit Project (MINAP) Steering Group. How the NHS cares for patients with heart attack. http://www.ucl.ac.uk/nicor/audits/minap/publicreports/pdfs/2012minappublicreportv2

8. Van de Werf F, Ardissino D, Betriu A, Cokkinos DV, Falk E, Fox KA, Julian D, Lengyel M, Neumann FJ, Ruzyllo W, Thygesen C, Underwood SR, Vahanian A, Verheugt FW, Wijns W. Management of acute myocardial infarction in patients presenting with ST-segment elevation. The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology. *Eur Heart J.* 2003;24:28-66.

9. Van de Werf F, Bax J, Betriu A, Blomstrom-Lundqvist C, Crea F, Falk V, Filippatos G, Fox K, Huber K, Kastrati A, Rosengren A, Steg PG, Tubaro M, Verheugt F, Weidinger F, Weis M. Management of acute myocardial infarction in patients presenting with persistent ST-segment elevation: the Task Force on the Management of ST-Segment Elevation Acute Myocardial Infarction of the European Society of Cardiology. *Eur Heart J.* 2008;29:2909-45.

10. Eurostat. General and regional statistics. In: 2006: Eurostat; 2012.

11. Oh EH, Imanaka Y, Evans E. Determinants of the diffusion of computed tomography and magnetic resonance imaging. *Int J Technol Assess Health Care.* 2005;21:73-80.

12. Network TR. Technological change around the world: evidence from heart attack care. *Health Aff (Millwood)*. 2001;20: 25-42.

13. OECD. A Disease-based Comparison of Health Systems. In: What is Best and at what Cost? Paris: Organisation for Economic Co-operation and Development, 2003:437.

14. Schmidt M, Jacobsen JB, Lash TL, Botker HE, Sorensen HT. 25 year trends in first time hospitalisation for acute myocardial infarction, subsequent short and long term mortality, and the prognostic impact of sex and comorbidity: a Danish nationwide cohort study. *BMJ.* 2012;344:e356.

15. Kalla K, Christ G, Karnik R, Malzer R, Norman G, Prachar H, Schreiber W, Unger G, Glogar HD, Kaff A, Laggner AN, Maurer G, Mlczoch J, Slany J, Weber HS, Huber K. Implementation of guidelines improves the standard of care: the Viennese registry on reperfusion strategies in ST-elevation myocardial infarction (Vienna STEMI registry). *Circulation.* 2006;113:2398-405.

16. Laut KG, Kaifoszova Z, Kristensen SD. Status of Stent for Life Initiative across Europe. *J Cardiovasc Med (Hagerstown)*. 2011;12:856-9.

17. Wennberg D, Dickens J Jr, Soule D, Kellett M Jr, Malenka D, Robb J, Ryan T Jr, Bradley W, Vaitkus P, Hearne M, O'Connor G, Hillman R. The relationship between the supply of cardiac catheterization laboratories, cardiologists and the use of invasive cardiac procedures in northern New England. *J Health Serv Res Policy.* 1997;2:75-80.

18. Aneja S, Ross JS, Wang Y, Matsumoto M, Rodgers GP, Bernheim SM, Rathore SS, Krumholz HM. US cardiologist workforce from 1995 to 2007: modest growth, lasting geographic maldistribution especially in rural areas. *Health Aff (Millwood).* 2011;30:2301-9.

19. Bech M. [Supply induces demand for health care services]. *Ugeskr Laeger*. 2010;172:785-7.

20. Garg PP, Landrum MB, Normand SL, Ayanian JZ, Hauptman PJ, Ryan TJ, McNeil BJ, Guadagnoli E. Understanding individual and small area variation in the underuse of coronary angiography following acute myocardial infarction. *Med Care.* 2002;40:614-26.

21. Mackenbach JP. The persistence of health inequalities in modern welfare states: the explanation of a paradox. *Soc Sci Med.* 2012;75:761-9.

22. Widimsky P, Fajadet J, Danchin N, Wijns W. "Stent 4 Life" targeting PCI at all who will benefit the most. A joint project between EAPCI, Euro-PCR, EUCOMED and the ESC Working Group on Acute Cardiac Care. *EuroIntervention.* 2009;4: 555-557.

23. Kristensen SD, Fajadet J, Di Mario C, Kaifoszova Z, Laut KG, Deleanu D, Gilard M, Guagliumi G, Goktekin O, Jorgova J, Kanakakis J, Ostojic M, Pereira H, Sabate M, Sobhy M, Vrints C, Wijns W, Widimsky P. Implementation of primary angioplasty in Europe: stent for life initiative progress report. *EuroIntervention.* 2012;8:35-42.

24. Goodacre S, Sampson F, Carter A, Wailoo A, O´Cathain A, Wood S, Capewell S, Campbell S. Evaluation of the National Infarct Angioplasty Project. In: National Co-ordinating Centre for NHS Service Delivery and Organisation R&D (NCCSDO); 2008, 169.

25. Bech M, Christiansen T, Dunham K, Lauridsen J, Lyttkens CH, McDonald K, McGuire A. The influence of economic incentives and regulatory factors on the adoption of treatment technologies: a case study of technologies used to treat heart attacks. *Health Econ.* 2009;18:1114-32.

26. Birkhead JS, Weston C, Lowe D. Impact of specialty of admitting physician and type of hospital on care and outcome for myocardial infarction in England and Wales during 2004-5: observational study. *BMJ.* 2006;332:1306-11.

27. OECD. The Looming Crisis In the Health Workforce - How can OECD countries respond? Paris: Organisation for Economic Co-operation and Development, 2008:66.

28. Sloan FA, Valvona J, Perrin JM, Adamache KW. Diffusion of surgical technology. An exploratory study. *J Health Econ.* 1986;5:31-61.

Online data supplement

Appendix. List of colleagues who gave support with the data collection.

Online Table 1. Data sources for the dependent variable - primary percutaneous coronary intervention by European country.

Online Table 2. Variables, description, data sources and hypothesised influence used for this study.

Online Table 3. Annual country- and region-specific changes in utilisation of primary percutaneous coronary intervention in 120 regions in 10 European countries 2003-2008.

Online data supplement

Appendix

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AUSTRIA. Dr Gerhard Fülöp, Gesundheit Österreich GmbH/Geschäftsbereich ÖBIG (Austrian Health Institute), Responsible for working area "health care planning", Stubenring 6, 1010 Vienna, Austria. Maria Hofmarcher-Holzhacker, Director Health and Care, European Centre for Social Welfare Policy and Research, Vienna, Austria.

BELGIUM. Professor Victor Legrand, MD, PhD, FESC, FACC, Department of Cardiology, CHU de Liège, Belgium.

DENMARK. The Danish Heart Register, The National Institute for Public Health. Lene Mia Von Kappelgaard, cand.sient.san.publ., Research assistant, National Institute of Public Health, Denmark. The National Board of Health, Denmark.

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GERMANY. Birga Maier, MD, MPH, MSc, Managing Director of the Berlin Myocardial Infarction Registry, Berlin. Professor Dr. med Heinz Theres, Medical Park Berlin Humboldtmühle, Berlin, Charité Universitätsmedicin Berlin, Germany. Diana Dinslage, employee of the health statistics at Federal Statistical Office, Germany. Helmut Schühlen, MD, FESC, FACC, Director of the Department of Cardiology & Invasive Care Medicine at the Vivantes Auguste-Viktoria-Klinikum in Berlin, Germany.

ITALY. Raffaele De Catarina, MD, PhD, Professor of Cardiology, Director at Institute of Cardiology, Institute of Cardiology, "G. d'Annunzio" University - Chieti-Pescara, Chieti, Italy. Aldo Pietro Maggioni, MD, FESC, Director ANMCO Research Center, Firenze, Italy.

PORTUGAL. Lino Gonçalves, MD, PhD, Department of Cardiology, Coimbra University Hospital, Portugal. Rui Cruz Ferreira, MD, National Coordinator for Cardiovascular Diseases, Lisbon, Portugal. Rui César das Neves, Engineer, National Cardiovascular Diseases Registry, Lisbon, Portugal.

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SPAIN. Manel Sabaté, MD, PhD, Chief of Department of Cardiology, Hospital Clínic, Barcelona. Héctor Bueno, MD, PhD, FESC, FAHA, Associate Professor of Medicine, Universidad Complutense de Madrid, Head of Clinical Cardiology/CCU Department of Cardiology, Hospital General Universitario Gregorio Maranon, President-Elect WG on Acute Cardiac Care, European Society of Cardiology, Spain.

SCOTLAND. Mr Adam Redpath, NHS National Services Scotland. Professor Jill Pell, Henry Mechan, Professor of Public Health, Institute of Health and Wellbeing, University of Glasgow.

NORTHERN IRELAND. Northern Ireland Statistical Research Agency, website: http://www.nisra.gov.uk/demography/default.asp.htm. Suzanna McVeigh, Assistant Statistician, Information and Analysis Directorate, Department of Health, Social Services and Public Safety Northern Ireland. Dr Sharon Jamison, Assistant Statistician Hospital Information Branch, Annexe 2 Castle Buildings, Stormont, Northern Ireland.

Online Table 1. Data sources for the dependent variable - primary percutaneous coronary intervention (PPCI) by European country.

Country/Years	Data source and content
Austria 2003-2008	Austrian Health Information System ÖGIS, registers all demographic and health-related data on the Austrian population. Based on the Ministry of Health statistics (http://www.goeg.at/en/Area/Austrian-Health-Information-OeGIS.html). Population-based registry - includes all hospitalised patients - information on hospital admissions since 1992. Registry is regarded representative. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration includes rescue and facilitated procedure (>12 hours from symptom onset). – No national PCI registry exists.
Belgium 2006-2008	Belgian registry of PCI - Belgian STEMI registry. Registration of all STEMI patients admitted to Belgian hospitals - includes 32 cardiac centres in Belgium. Registry is regarded representative. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration includes rescue and facilitated procedures (>12 hours from symptom onset). – No national PCI registry exists.
Denmark 2003-2008	Danish Heart registry (http://www.dhreg.dk/uk/default.shtml). A national clinical database of invasive cardiology and heart surgery. Population-based registry - includes all coronary angiographics and revascularisations by PCI and CABG at Danish hospitals since the year 2000. Registry is regarded representative. PPCI defined as PPCI (procedure codes KNFG05A, KNFG02A) in patients with diagnosed STEMI (ICD-10). – Registration includes rescue and facilitated procedures (>12 hours from symptom onset).
England 2003-2008	MINAP registry - Myocardial Ischaemia National Audit Project (http://www.hqip.org.uk/). Established in 1999 in order to examine the quality of management of heart attacks in England and Wales. Includes all hospitals in England and Wales. However, no mandatory registration but registry is regarded representative. Includes amongst others registration of pre-hospital thrombolysis and primary percutaneous intervention. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration does not include rescue and facilitated procedures
Germany 2005-2008	National statistics Germany "Statistisches Bundesamt" (https://www.destatis.de/EN/Homepage.html) The national statistics bureau of Germany. Registers all national demographic and health-related data on the German population. Registry is regarded representative. PPCI defined as PPCI (procedure code OPS-8-837 [OPS version 2009]) in patients with diagnosed STEMI (ICD-10) – Registration includes rescue and facilitated procedures (>12 hours from symptom onset). – No national PCI registry exists.
Italy 2003-2008	GISE registry, Italian Society of Interventional Cardiology. Registration of coronary angiographics and revascularisations by PCI and CABG at all Italian hospitals (http://www.gise.it/). Registry is regarded representative. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10) – Registration includes rescue and facilitated procedures (>12 hours from symptom onset).
Northern Ireland 2003-2008	Northern Ireland Statistics and Research Agency (NISRA) (http://www.nisra.gov.uk/). NISRA is the principal source of official statistics and social research in Northern Ireland. Population-based registry - includes all hospitalised patients - information on hospital admissions since 2000. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration includes rescue and facilitated procedures (>12 hours from symptom onset).
Portugal 2003-2008	National initiative to register and monitor cardiovascular diseases and treatment in Portugal. Controlled by the Office of the commissioner of Health. National cardiovascular working group. Registration of cardiovascular disease and treatment since 2007. Registry is regarded representative. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10) – Registration includes rescue and facilitated procedures (>12 hours from symptom onset).
Spain 2004-2008	Spanish Cardiac Catheterisation and Coronary Intervention Registry. Registration began in 1990. Publishes annual reports - data analysed by the steering committee of the Working Group. No mandatory registration, however the registry comprises most cardiac catherisation laboratories in Spain. Participation rate has been increasing. Registry is regarded representative. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Until 2007 the registration includes rescue and facilitated procedures (>12 hours from symptom onset).
Sweden 2004-2008	SWEDEHEART/SCAAR registry. SWEDEHEART is a national registry of all patients hospitalised for acute coronary syndrome (ACS) or undergoing coronary or valvular intervention for any indication. Established in 2009. Consists of the following registries: Heart Intensive Care Admissions (RIKS-HIA, 1990), the Swedish Coronary Angiography and Angioplasty Registry (SCAAR, 1998), and the Swedish Heart Surgery Registry and the National Registry of Secondary Prevention (SEPHIA, 1992) (http://www.ucr.uu.se/swedeheart/). PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration does not include rescue and facilitated procedures.
Wales 2003-2008	MINAP registry - Myocardial Ischaemia National Audit Project (http://www.hqip.org.uk/). Established in 1999 in order to examine the quality of management of heart attacks in England and Wales. Includes all hospitals in England and Wales. However, no mandatory registration but registry is regarded representative. Includes amongst others registration of pre-hospital thrombolysis and primary percutaneous intervention. PPCI defined as PPCI in patients with diagnosed STEMI (ICD-10). – Registration does not include rescue and facilitated procedures.

Online Table 2. Variables, description, data sources and hypothesised influence used for this study.

Topic	Variable	Description	Data source	Year	Hypothesised influence
Demand factors					
Social and demographic variables (population structure)	Prevalence of STEMI	(ICD-10 DI21.0, 21.1, 21.2, 21.3, 21.9) Defined as the annual in-hospital discharges of STEMI	National statistics	2003-2008	
	Population	Total population January 1st	EUROSTAT*	2006	
	Age	Age <30 Proportion of population aged 30 years or less	EUROSTAT*		÷
		Age 30-<50 Proportion of population aged 30-49 years	EUROSTAT*	2006	+
		Age 50-<70 Proportion of population aged 50-69 years	EUROSTAT*	2006	+
		Age 70+ Proportion of population aged 70 years or more	EUROSTAT*	2006	÷
	Gender	Proportion of males in the country	EUROSTAT*	2006	+
	Life expectancy	Estimated life expectancy, males and females	EUROSTAT*	2006	+
Supply factors					
Supply of healthcare services	Numbers of PPCI	Emergency procedure within 12 hrs, national procedure coding. NORMESCO coding (Nordic Medico-Statistical Committee) (FNG05A, FNG02A) was used in the Nordic countries. Some countries were not able to provide time-specified procedure codes. Here procedures are defined as PPCI in patients with STEMI. Where not specified these codes include both urgent and rescue procedures. Most countries do not register the time factor.	National statistics (see Online Table 1)	2003-2008	
	Number of physicians per 100,000 population	Medical group of specialties includes, e.g., cardiology, internal medicine and gastroenterology. Full-time equivalent, working in hospital	EUROSTAT*	2006	+
	Number of nurses and midwives per 100,000 population	Nurses and midwives working in hospital Full-time equivalent	EUROSTAT*	2006	+
	Number of acute care hospital beds per 100,000 population	Curative care beds in hospitals or hospital department with average length of stay 18 days or less	EUROSTAT*	2006	–
	Educational level	Percentage of people between 25 and 64 years old who have completed the highest levels of schooling according to the International Standard Classification of Education (ISCED) system Group 5 & 6	EUROSTAT*	2006	+
	GDP per capita	Gross domestic product per capita in purchasing power parity (PPP) euro	EUROSTAT*	2006	+
Framework conditions					
	Population density	Average population density per square km	EUROSTAT*	2006	+
	Hospital remuneration scheme	1) Global budget 2) Fee-for-service 3) Per discharge (DRG)	National statistics bureaus European Observatory HIT country reports**	2006	– ÷ +
	Physician remuneration scheme	1) Fee-for-service 2) Fixed salary	National statistics bureaus European Observatory HiT country reports**	2006	+ –

*The Statistical Office of the European Union (Eurostat) was established in 1953. Eurostat collects and verifies national- and regional-level statistics from the statistical authorities of the member countries. Eurostat ensures comparable data across countries and regions over time. The European Statistical System undertakes quality-reporting, which can be consulted at the Eurostat homepage (http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/introduction). **The European Observatory on Health System and Policies is a partnership among several European Health Institutions and local governments that supports and promotes evidence-based health policy-making through comprehensive and rigorous analysis of healthcare systems in Europe. In order to maximise comparability across countries, a standard template and questionnaire are used when producing country reports (HiTs) (www.euro.who.int/observatory/Hits).

Online Table 3. Annual country- and region-specific changes in utilisation of primary percutaneous coronary intervention in 120 regions in 10 European countries 2003-2008.

Country	Regions	Population 1 Jan 2006	PPCI per mill 2003	PPCI per mill 2008	Overall country-specific annual change in PPCI use (2003-2008) Coefficient (95% CI)	Region-specific annual change in PPCI (2003-2008) Coefficient (95% CI)
Austria	Burgerland	279,128	147	595	1.17 (1.10, 1.25)	1.32 (1.13, 1.54)
	Carinthia	559,277	288	578		1.15 (1.10, 1.21)
	Lower Austria	1,580,501	444	790		1.13 (1.05, 1.21)
	Salzburg	524,920	518	634		1.04 (0.94, 1.14)
	Styria	1,200,854	250	699		1.25 (1.14, 1.37)
	Tyrol	694,253	222	421		1.16 (1.07, 1.25)
	Upper Austria	1,400,287	400	598		1.08 (1.02, 1.14)
	Vienna	1,652,448	447	661		1.09 (1.02, 1.17)
	Vorarlberg	362,630	88	400		1.36 (1.28, 1.45)
Belgium	Antwerpen	1,688,493	781	970	1.04 (0.70, 1.57)	1.36 (0.70, 2.66)
	Brabant Wallon	366,481	0	0		0
	Bruxelles	1,018,804	0	0		0
	Hainaut	1,290,079	0	0		0
	Liège	1,040,297	0	0		0
	Limburg	814,658	0	0		0
	Luxemburg	258,547	0	0		0
	Namur	458,574	0	0		0
	Oost-Vlaanderen	1,389,450	589	487		0.85 (0.67, 1.08)
	Vlaams Brabant	1,044,133	1290	1250		0.98 (0.91, 1.06)
	West-Vlaanderen	1,141,866	0	0		0
Denmark	Capital Region of Denmark	1,636,749	306	286	1.04 (0.98, 1.10)	0.99 (0.95, 1.04)
	Central Denmark Region	1,227,428	567	475		0.95 (0.92, 0.99)
	The North Denmark Region	576,972	361	575		1.13 (0.98, 1.32)
	The South Denmark Region	1,189,817	307	484		1.09 (1.01, 1.16)
	Region Zealand	816,118	512	598		1.05 (1.00, 1.16)
England and Wales	East of England	7,546,000	37	208	1.29 (1.15, 1.43)	1.35 (1.06, 1.71)
	East Midlands	4,345,900	15	171		1.41 (0.84, 2.37)
	London	7,484,200	18	102		1.36 (0.93, 1.98)
	North East	2,552,700	34	143		1.40 (1.01, 1.95)
	North West	6,846,500	27	129		1.43 (1.04, 1.95)
	South East Coast	3,983,000	261	91		0.94 (0.44, 2.04)
	South Central	5,123,000	23	90		1.47 (1.06, 2.04)
	South West	5,289,000	33	129		1.44 (1.04, 1.99)
	Wales	2,959,700	165	108		0.82 (0.52, 1.30)
	West Midlands	5,358,700	53	126		1.28 (0.73, 2.22)
	Yorkshire	5,125,000	61	275		1.46 (1.09, 1.95)
Germany	Baden-Württemberg	10,735,701	683	636	0.99 (0.94, 1.04)	0.98 (0.95, 1.00)
	Bayern	12,468,726	651	617		0.98 (0.97, 0.99)
	Berlin	3,395,189	879	724		0.94 (0.92, 0.96)
	Brandenburg	2,559,483	613	628		1.01 (0.97, 1.05)
	Bremen	663,700	1315	1342		1.02 (0.94, 1.10)
	Hamburg	1,743,627	924	736		0.94 (0.81, 1.20)

Online Table 3. Annual country- and region-specific changes in utilisation of primary percutaneous coronary intervention in 120 regions in 10 European countries 2003-2008. (Cont'd)

Country	Regions	Population 1 Jan 2006	PPCI per mill 2003	PPCI per mill 2008	Overall country-specific annual change in PPCI use (2003-2008) Coefficient (95% CI)	Region-specific annual change in PPCI (2003-2008) Coefficient (95% CI)
Germany (Cont'd)	Hessen	6,092,354	763	686		0.97 (0.93, 1.00)
	Mecklenburg	1,707,266	871	838		0.98 (0.91, 1.06)
	Niedersachsen	7,993,946	588	663		1.04 (0.98, 1.10)
	Nordrhein-Westfalen	18,058,105	700	718		1.00 (0.98, 1.04)
	Rheinland	4,058,843	574	592		1.02 (0.95, 1.09)
	Saarland	1,050,293	1042	970		0.98 (0.89, 1.07)
	Sachsen	4,273,754	626	625		0.99 (0.95, 1.05)
	Sachsen-Anhalt	2,469,716	568	575		1.00 (0.94, 1.08)
	Schleswig-Holstein	2,832,950	690	668		0.99 (0.94, 1.04)
	Thüringen	2,334,575	742	641		0.96 (0.91, 1.00)
Italy	Abruzzo	1,305,307	147	259	1.18 (1.10, 1.26)	1.10 (1.01, 1.20)
	Aosta Valley	123,978	0	121		0
	Basilicata	594,086	162	101		0.93 (0.75, 1.15)
	Bolzano-Bozen	482,650	203	491		1.17 (1.04, 1.31)
	Calabria	2,004,415	18	185		1.43 (1.12, 1.83)
	Campania	5,790,929	48	216		1.30 (1.11, 1.51)
	Emilia-Romagna	4,187,557	301	641		1.17 (1.09, 1.25)
	Friuli-Venezia Giulia	1,208,278	80	409		1.37 (1.18, 1.59)
	Lazio	5,304,778	141	331		1.18 (1.07, 1.30)
	Liguria	1,610,134	258	591		1.18 (1.11, 1.26)
	Lombardy	9,475,202	346	552		1.10 (1.08, 1.12)
	Marche	1,528,809	108	313		1.26 (1.05, 1.52)
	Molise	320,907	0	168		1.89 (0.37, 9.72)
	Piedmont	4,341,733	216	457		1.16 (1.11, 1.22)
	Puglia/Apulia	4,071,518	49	307		1.47 (1.30, 1.66)
	Sardinia	1,655,677	144	358		1.22 (1.13, 1.31)
	Sicily	5,017,212	154	393		1.21 (1.09, 1.35)
	Trento	502,478	171	322		1.11 (1.04, 1.19)
	Tuscany	3,619,872	440	594		1.07 (1.05, 1.09)
	Umbria	867,878	128	366		1.24 (1.12, 1.39)
	Veneto	4,738,313	232	377		1.11 (1.07, 1.15)
Northern Ireland	Eastern	666,910	91	105	1.10 (0.82, 1.47)	1.00 (0.88, 1.13)
	Northern	444,700	20	34		–
	Southern	334,800	0	134		–
	Western	293,000	0	0		–
Portugal	Algarve	416,847	408	581	1.14 (0.19, 6.86)	1.43
	Allentejo	765,971	22	20		0.88
	Central Region	2,382,448	137	154		1.12
	Lisbon	2,779,097	321	394		1.23
	Northern Region	3,737,791	128	142		1.11
Spain	Andalucia	7,794,121	129	199	1.15 (1.07, 1.24)	1.16 (0.99, 1.37)
	Aragon	1,258,847	142	173		1.11 (0.84, 1.46)

Online Table 3. Annual country- and region-specific changes in utilisation of primary percutaneous coronary intervention in 120 regions in 10 European countries 2003-2008. (Cont'd)

Country	Regions	Population 1 Jan 2006	PPCI per mill 2003	PPCI per mill 2008	Overall country-specific annual change in PPCI use (2003-2008) Coefficient (95% CI)	Region-specific annual change in PPCI (2003-2008) Coefficient (95% CI)
Spain (Cont'd)	Asturias	1,058,330	62	141		1.25 (1.12, 1.39)
	Balearic Islands	985,620	201	327		1.11 (1.04, 1.19)
	Basque Country	2,113,052	250	363		1.09 (1.00, 1.18)
	Canary Islands	1,953,361	187	455		1.21 (0.97, 1.51)
	Cantabria	557,226	139	227		1.12 (0.91, 1.37)
	Catalonia	6,936,148	76	225		1.32 (1.24, 1.41)
	Castilla-La Mancha	1,892,657	128	288		1.24 (1.09, 1.41)
	Castilla y Leon	2,477,128	184	314		1.15 (1.11, 1.19)
	Extremadura	1,071,339	86	232		1.37 (0.96, 1.95)
	Galicia	2,718,490	255	364		1.09 (0.96, 1.24)
	Madrid	2,481,600	108	119		1.03 (0.94, 1.12)
	Murcia	1,335,347	235	398		1.15 (1.07, 1.24)
	Navarra	588,306	465	453		1.01 (0.86, 1.17)
	La Rioja	300,821	0	0		0
	Valencia Community	4,641,240	125	160		1.05 (1.00, 1.11)
Sweden	Blekinge County	151,436	310	429	1.26 (1.08, 1.46)	1.05 (0.90, 1.23)
	Dalarna County	275,711	196	399		1.19 (0.99, 1.43)
	Gotland County	57,297	17	52		1.39 (1.12, 1.72)
	Gävlborg County	275,653	174	580		1.37 (1.24, 1.51)
	Halland County	288,859	83	429		1.43 (0.83, 2.45)
	Jämtland County	127,020	31	39		1.05 (0.40, 2.72)
	Jönköping County	331,539	36	510		1.83 (0.94, 3.55)
	Kalmar County	233,776	287	586		1.20 (0.99, 1.45)
	Kronoberg County	179,635	206	390		1.16 (0.95, 1.42)
	Norrbotten County	251,886	67	32		0.74 (0.42, 1.30)
	Skåne County	1,184,500	312	494		1.11 (0.98, 1.26)
	Stockholm County	1,918,104	111	288		1.23 (0.91, 1.66)
	Södermanland County	263,099	106	513		1.50 (1.07, 2.12)
	Örebro County	275,030	229	476		1.18 (0.97, 1.45)
	Östergötland County	417,966	175	426		1.23 (0.80, 1.89)
	Uppsala County	319,925	169	403		1.26 (1.05, 1.52)
	Värmland County	273,489	48	570		1.90 (1.01, 3.55)
	Väsmanland County	248,489	225	519		1.19 (0.90, 1.57)
	Västerbotten County	257,581	217	311		1.57 (0.88, 1.27)
	Västernorrland County	243,978	16	135		1.53 (0.80, 2.92)
	Västra Götaland County	1,538,284	101	389		1.34 (0.90, 2.00)