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CURRENT OPINION
Interventional cardiology

Mapping interventional cardiology in Europe: the European Association of Percutaneous Cardiovascular Interventions (EAPCI) Atlas Project

Emanuele Barbato[1]*, Marko Noc[2], Andreas Baumbach [3], Dariusz Dudek[4], Matjaz Bunc[5], Emmanouil Skalidis [6], Adrian Banning [7], Jacek Legutko [8], Nils Witt [9], Manuel Pan [10], Hans-Henrik Tilsted[11], Holger Nef[12], Giuseppe Tarantini[13], Dzianis Kazakiewicz[14], Radu Huculeci [14], Stephane Cook [15], Ahmed Magdy [16], Walter Desmet [17], Guillaume Cayla[18], Dragos Vinereanu[19], Michiel Voskuil[20], Omer Goktekin[21], Panos Vardas[22], Adam Timmis[3], and Michael Haude[23]

[1]Department of Advanced Biomedical Sciences, University of Naples Federico II, Via Pansini n. 5, 80131 Naples, Italy; [2]Center for Intensive Internal Medicine, University Medical Center, Ljubljana, Slovenia; [3]Queen Mary University of London, Barts Heart Centre, London, UK; [4]Institute of Cardiology, Jagiellonian University, Kopernika 17, Krakow, Poland; [5]University Clinical Center Ljubljana, Zaloška c. 004, Ljubljana, Slovenia; [6]Cardiology Department, Heraklion University Hospital; [7]Oxford Heart Centre, Oxford University Hospitals, Headley Way, Oxford OX3 9DU, UK; [8]Department of Interventional Cardiology, Institute of Cardiology, Jagiellonian University Medical College, John Paul II Hospital, Krakow, Poland; [9]Department of Clinical Science and Education, Karolinska Institutet, Unit of Cardiology, Södersjukhuset, Stockholm, Sweden; [10]Reina Sofía Hospital, Department of Cardiology, University of Córdoba (IMIBIC), Spain; [11]Department of Cardiology, Rigshospitalet, University of Copenhagen, Denmark; [12]University of Giessen, Department of Cardiology and Angiology, Germany; [13]Interventional Cardiology, Department of Cardiac Thoracic and Vascular Science University of Padua, Italy; [14]European Society of Cardiology Health Policy Unit, European Heart Health Institute, European Heart Agency, Brussels, Belgium; [15]Cardiology, University Hospital Fribourg, Switzerland; [16]National Heart Institute, Cairo, Egypt; [17]Department of Cardiovascular Diseases, University Hospital Leuven, and Department of Cardiovascular Sciences, KU Leuven, Leuven, Belgium; [18]Department of cardiology, University of Montpellier, Nimes, France; [19]University of Medicine and Pharmacy Carol Davila, University and Emergency Hospital, Bucharest, Romania; [20]Department of Cardiology, University Medical Center Utrecht, The Netherlands; [21]Bahcelievler Memorial Hospital, Istanbul, Turkey; [22]Heart Sector, Hygeia Group Hospitals, 5 Erythrou Stavrou Str, 151 23, Marousi, Athens, Greece; and [23]Städtische Kliniken Neuss, Lukaskrankenhaus GmbH, Neuss, Germany

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Aims The European Association of Percutaneous Cardiovascular Interventions (EAPCI) Atlas of Interventional Cardiology has been developed to map interventional practice across European Society of Cardiology (ESC) member countries. Here we present the main findings of a 16-country survey in which we examine the national availability of interventional infrastructure, human resource, and procedure volumes.

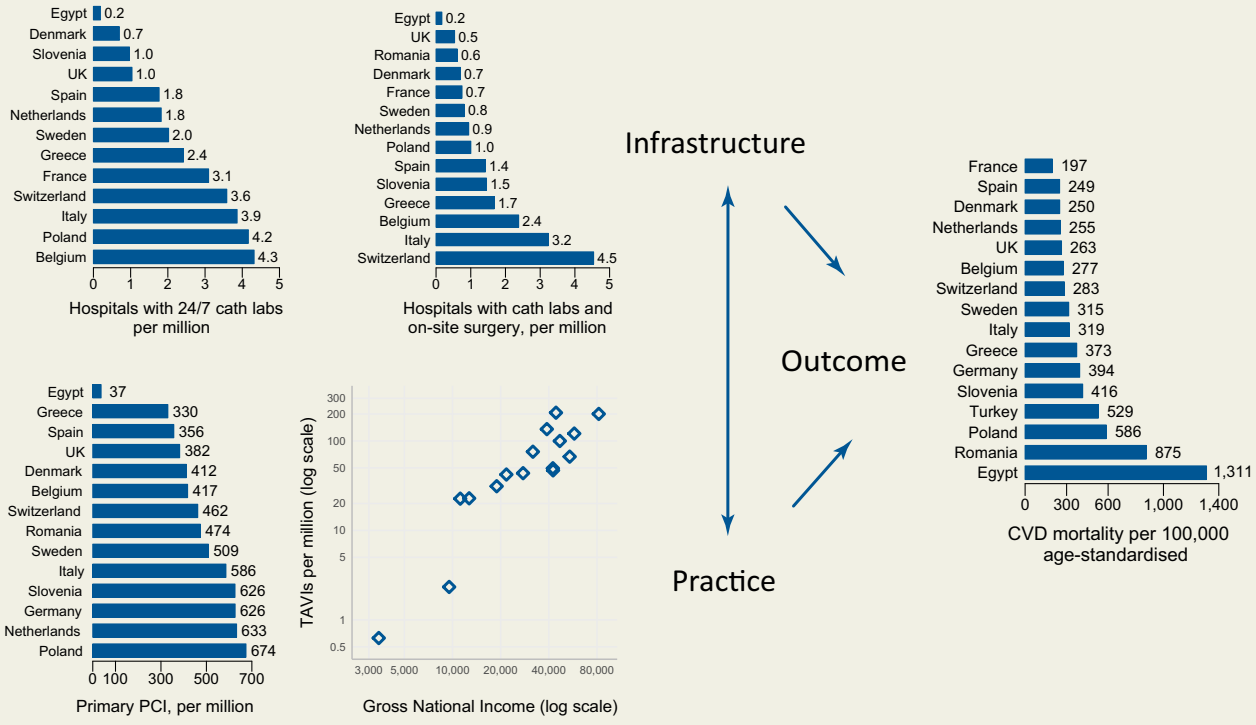
Methods and results Sixteen ESC member countries participated in the EAPCI Atlas survey. Interventional data were collected by the National Cardiac Society of each participating country. An annual median of 5131 [interquartile range (IQR) 4013–5801] diagnostic heart procedures per million people were reported, ranging from <2500 in Egypt and Romania to >7000 in Turkey and Germany. Procedure rates showed significant correlation ($r = 0.67$, $P = 0.013$) with gross national income (GNI) per capita. An annual median of 2478 (IQR 1690–2633) percutaneous coronary interventions (PCIs) per million people were reported, ranging from <1000 in Egypt and Romania to >3000 in Switzerland, Poland, and Germany. Procedure rates showed significant correlation with GNI per capita ($r = 0.62$, $P = 0.014$). An annual median of 48.2 (IQR 29.1–105.2) transcatheter aortic valve implantation procedures per million people were performed, varying from <25 per million people in Egypt, Romania, Turkey, and Poland to >100 per million

* Corresponding author. Tel: +39 0817462211, Fax: +39 0817462211, Email: emanuele.barbato@unina.it

people in Denmark, France, Switzerland, and Germany. Procedure rates showed significant correlation with national GNI per capita ($r = 0.92$, $P < 0.001$).

Conclusion The first report from the EAPCI Atlas has shown considerable international heterogeneity in interventional cardiology procedure volumes. The heterogeneity showed association with national economic resource, a reflection no doubt of the technological costs of developing an interventional cardiology service.

Graphical Abstract



Keywords EAPCI • Interventional cardiology • Europe • ESC Atlas

Introduction

The European Association of Percutaneous Cardiovascular Interventions (EAPCI), in association with the European Society of Cardiology (ESC), has surveyed 16 of its member countries in order to examine heterogeneity in interventional infrastructure, human resource, and procedure volumes. An EAPCI manual of definitions was made available to all the participating countries in order to help standardize key statistics included in the survey. The survey benefited from support by the ESC's European Heart Agency which has developed considerable experience in international data collection based on its pioneering ESC Atlas Project.[1]

The EAPCI has been active in promoting the interventional management of coronary artery disease and valvular heart disease through its Stent-for-Life and Valve-for-Life programmes which, among other aims, seek to reduce obstacles to the implementation of interventional treatment among participating countries according to the recommendations of international guidelines.[2,3] However, mechanisms for monitoring national implementation of interventional technologies are unavailable and the EAPCI Atlas of Interventional Cardiology survey (henceforth referred to as the EAPCI Atlas) seeks to resolve this unmet need by independent collection of high-quality data pertaining to interventional cardiovascular healthcare delivery. By collecting data across international boundaries, the EAPCI Atlas will provide a resource for policymakers in benchmarking standards of care and auditing the implementation of guideline recommendations in participating countries.[4,5]

In the first edition of the EAPCI Atlas, we present the main findings of the 16-country survey and attempt to identify some of the factors that modify interventional practice. We examine the national availability of interventional infrastructure, human resource, and

Table 1 Descriptive characteristics, infrastructure and procedure volumes in the 16-country survey

Data are for 2016 or latest year	GNI per capita (USD)	Prevalence of ischaemic heart disease per million people	Age-standardized CVD mortality per 100 000 people	Interventional cardiologists per million people	Hospitals with catheterization laboratories per million people	Diagnostic heart procedures per million people	PCI procedures per million people	Primary PCI procedures per million people	TAVI procedures per million people	Percutaneous mitral valve repair procedures per million people
High income										
Switzerland	81 240	25 500	283	27.1	4.5	6480	3187	461.8	200.4	44.2
Denmark	56 730	29 171	250	15.7	2.3	4926	1758	411.8	120.9	4.9
Sweden	54 630	38 700	315	13.8	3	4142	2147	508.5	66.7	2.6
The Netherlands	46 310	34 641	255	10.2	4.3	U/A	2468	632.7	99.9	U/A
Germany	43 660	34 122	394	53.3	U/A	9392	3852	626.3	206.8	64.1
UK	42 390	33 608	263	10.1	2.7	3969	1485	382.3	49.5	2.3
Belgium	41 860	28 963	277	23.6	4.3	U/A	2488	417.2	46.9	7
France	38 950	26 412	197	20.9	3.1	5232	2588	U/A	135.5	2.9
Italy	31 590	34 705	319	17.7	4.4	5849	2540	585.7	75.8	16.3
Spain	27 520	26 619	249	15	2.3	3324	1479	356.4	43.6	5.3
Slovenia	21 660	44 795	416	17.9	3.4	5414	2631	625.7	42.1	3.9
Greece	18 960	32 536	373	20.9	4.9	5030	1983	330.2	31.2	5.3
Poland	12 680	42 017	586	15.1	4.2	5657	3200	674	22.8	3.7
Upper-middle income										
Turkey	11 180	23 782	529	20.3	3.6	7043	2641	U/A	22.6	>U/A
Romania	9470	47 090	875	4.3	1.8	2171	937	473.5	2.3	0.2
Lower-middle income										
Egypt	3460	17 227	1311	4.4	1	732	564	36.6	0.6	0

TAVI, transcatheter aortic valve implantation.

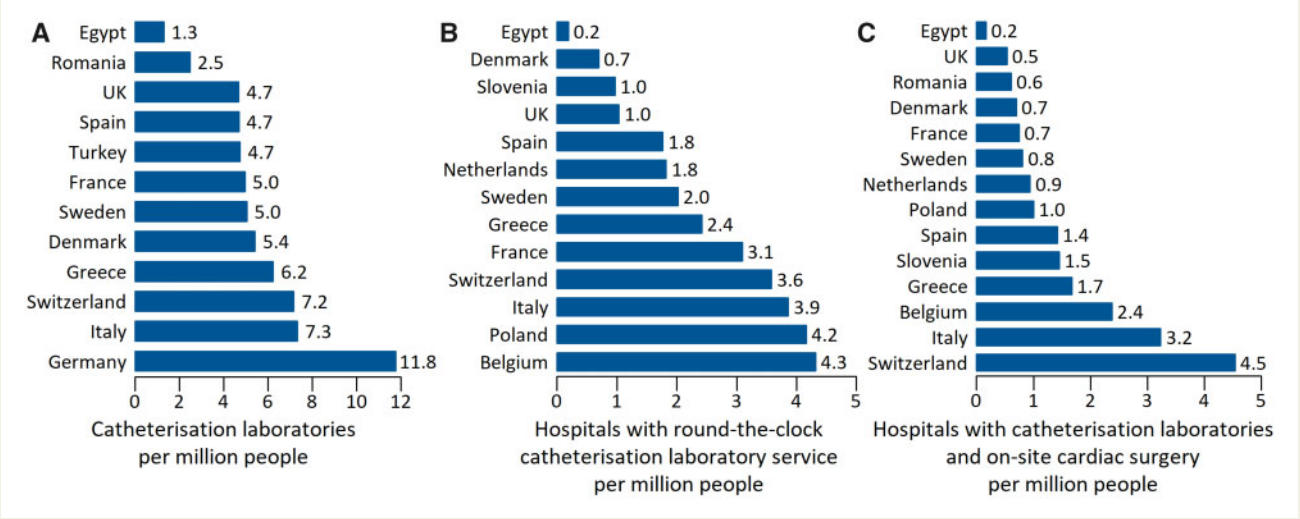


Figure 1 (*A*) Total number of catheterization laboratories (2016 or latest available year). (*B*) Number of hospitals providing round-the-clock catheterization laboratory service (2016 or latest available year). (*C*) Number of hospitals with catheterization laboratories and on-site cardiac surgery (2016 or latest available year). All data per million, sourced from EAPCI survey. Data not available: (*A*) Belgium, Netherlands, Poland, Slovenia; (*B*) Germany, Romania, Turkey; (*C*) Germany, Turkey.

document procedural volumes. Special emphasis is given to determining how heterogeneity in interventional healthcare maps to national differences in income status.

Methods

Participating countries

A convenience sample of 16 ESC member countries participated in the EAPCI Atlas survey. They were Belgium, Denmark, Egypt, France, Germany, Greece, Italy, the Netherlands, Poland, Romania, Slovenia, Spain, Sweden, Switzerland, Turkey, and UK (*Table 1*).

Data collection

On request by the EAPCI task force, interventional data were collected by the National Cardiac Society (NCS) of each participating country, either by local inquiry or from national registries, and were recorded in an electronic case report form (e-CRF). In collecting the data, partnership with the EHA allowed exploitation of the existing ESC-Atlas platform.[6]

Data quality assurance

Steps to ensure data quality in the EAPCI Atlas were based on those previously developed in the main ESC Atlas programme[1]:

(1) The questionnaire used to collect data was reviewed by internal experts (the EAPCI Atlas Task Force), by the Executive Board and by the EHA.
(2) A manual, based on international definitions and specially developed by the EAPCI, was used by all participating NCSs or Working Groups of interventional cardiology to ensure consistent data collection (Appendix 1).
(3) The e-CRF used to collect the data contained integrated logical checks and metadata information for data quality purposes.
(4) Data collected in the EAPCI Atlas were cross-checked with other data sets collected in the main ESC Atlas, or available in the literature.
(5) Comparative indicators were constructed to identify unusual differences and outliers. Systematic checks were programmed to identify illogical answers.
(6) Data sets and country profiles were reviewed and approved by the NCS or Working Group of interventional cardiology prior to finalization.
(7) Data sets were processed, checked, and validated by EHA biostatisticians using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Data presentation

Data are for 2016 or latest year available. Presentation is descriptive and adjusted for population size by reporting values per million people. National income status for the 16 countries was defined by World Bank criteria for 2016/17 as follows[7]:

- Lower-middle income: Gross national income (GNI) per capita $1026 to $4035;
- Upper-middle income: GNI per capita $4036 to $12 475;
- High income: GNI per capita ≥$12 476 or more.

Data analysis

An aggregate of national data was the unit of analysis for statistics recorded in the EAPCI Atlas. Averaged data across the 16 participating countries are presented as medians with interquartile range (IQR) in parentheses. Non-parametric (permutation-based) correlation coefficient testing was used to test the significance of associations between two variables. The Pearson's correlation coefficient was calculated for log-transformed data and for 100 000 random permutations of the data to test the null hypothesis that variables were independent.[8] We made no assumption of causation when associations were identified.

Results

Of the 16 countries included in the EAPCI Atlas survey, World Bank criteria categorized Egypt as lower-middle income, Romania and Turkey as upper-middle income, and the remainder as high income. For each country, GNI per capita, mortality data for cardiovascular disease (CVD) and rates of selected coronary and structural heart interventions are listed in *Table 1*.

National infrastructure

In the 16-country survey, the median number of hospitals with catheterization laboratories was 3.4 (IQR 2.5–4.3) per million people, ranging from 1 in Egypt to almost 4.9 in Greece (*Table 1*). The total number of catheterization laboratories ranged from 1.3 per million people in Egypt to 11.8 in Germany, with a median across all countries of 5.0 (IQR 4.7–6.5) or 1.5 per hospital (*Figure 1A*). A round-the-clock service was provided by 67% of hospitals with catheterization laboratories [median 2.0 (IQR 1.0 to 3.6) per million people], ranging from 0.2 per million in Egypt to >4 per million in Poland and Belgium (*Figure 1B*). Cardiac surgery was offered by 41% of hospitals with catheterization laboratories [median 0.9 (IQR 0.8 to 1.8) per million people], ranging from 0.2 per million in Egypt to 4.5 per million in Switzerland (*Figure 1C*). Hospitals per million inhabitants equipped to perform structural heart interventions, varied from 0.2 in Egypt to 4.5 in Switzerland.

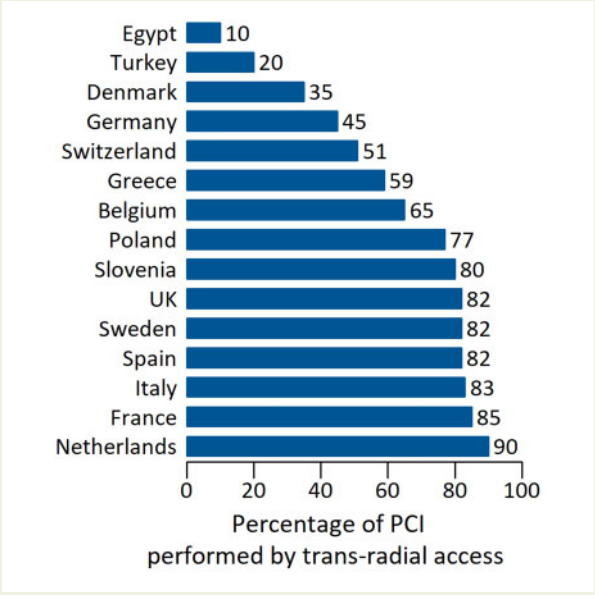


Figure 2 Percutaneous coronary intervention: utilization of radial access (2016). Data not available: Romania.

Human resource

In the 16-country survey, there were a median of 16.7 (IQR 12.9 to 20.9) interventional cardiologists per million people, ranging from 4.3 per million in Romania to 53.3 per million in Germany (*Table 1*).

Procedure volumes

a. *Diagnostic heart procedures.* An annual median of 5131 (IQR 4013–5801) diagnostic heart procedures per million people were reported in 2016, ranging from <2500 in Egypt and Romania to >7000 in Turkey and Germany. Data for Belgium and Netherlands were unavailable (*Table 1*). There was significant correlation between rates of diagnostic cardiac catheterization and GNI per capita (r = 0.67, P =0.013) (Supplementary material online, *Figure S1A*).

b. *Percutaneous coronary interventions.* An annual median of 2478 (IQR 1690–2633) percutaneous coronary interventions (PCIs) per million people were reported in 2016, ranging from <1000 in Egypt and Romania to >3000 in Switzerland, Poland, and Germany (*Table 1*). Trans-radial access was used in >50% of cases in all countries except Egypt, Turkey, Germany, and Denmark (data unavailable: Romania) (*Figure 2*). There was significant correlation between rates of PCI and

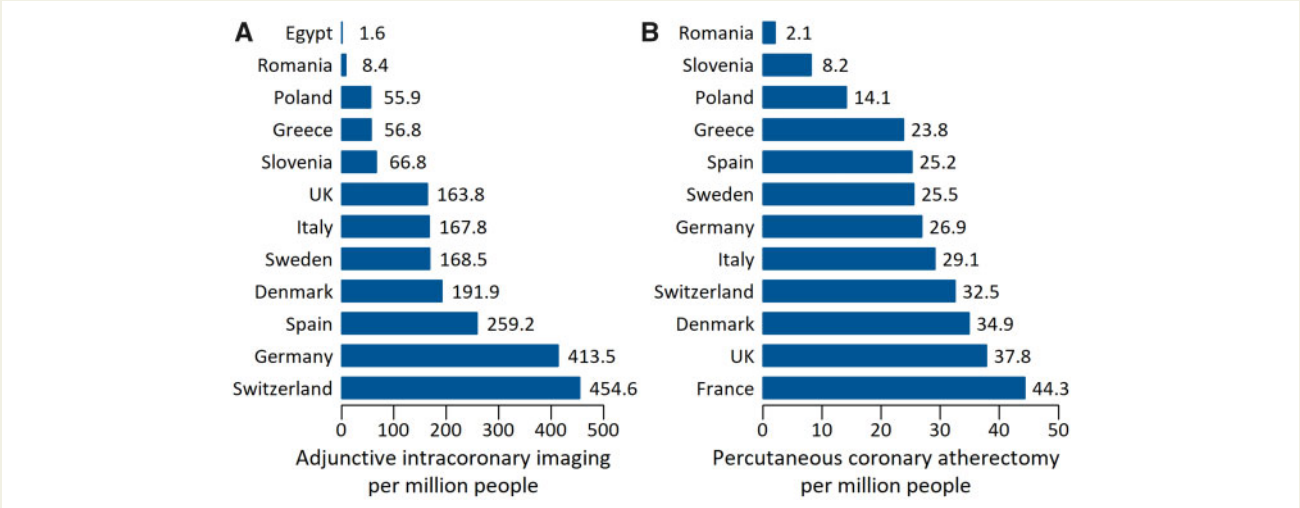


Figure 3 (*A*) Adjunctive intracoronary imaging per million people (2016 or latest available year). (*B*) Percutaneous coronary atherectomy per million people (2016 or latest available year). Data not available: (*A*) Belgium, France, Netherlands, Turkey; (*B*) Belgium, Netherlands, Turkey. Procedure not available: (*B*) Egypt.

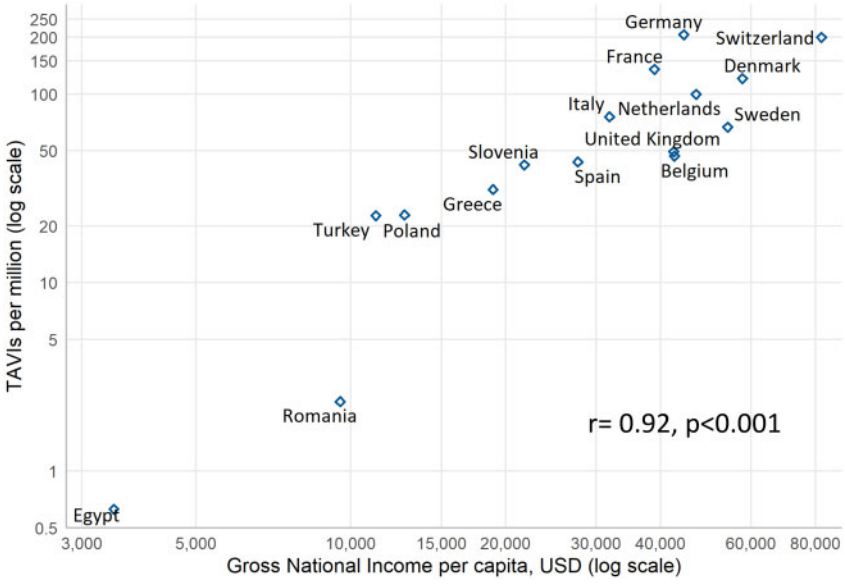


Figure 4 Transcatheter aortic valve implantations per million people by gross national income (GNI) per capita (2016 or latest available year).

GNI per capita (r = 0.62, P =0.014) (Supplementary material online, *Figure S1B*).

c. *Primary percutaneous coronary interventions (pPCI).* Across participating countries, a median of 468 (IQR 390–616) cases of pPCI per million people were reported for 2016 (data unavailable: France, Turkey), but variation was considerable ranging from only 37 cases per million people in Egypt to >600 cases per million people in Slovenia, Germany, the Netherlands, and Poland (*Table 1*).

d. *Adjunctive technologies.* Rates of intracoronary imaging during PCI [median 166 (IQR 57–209) per million people] ranged from <10 per million people in Egypt and Romania to >400 per million people in Germany and Switzerland (data unavailable: Belgium, France, the Netherlands, and Turkey) (*Figure 3A*). There was similar variation in use of rotational or orbital atherectomy during PCI [median 25.6 (IQR 14.1 to 32.5) per million people] ranging from 2.1 per million people in Romania to 44.3 per million people in France (data unavailable: Belgium, the Netherlands, Turkey; procedure unavailable: Egypt) (*Figure 3B*).

e. *Transcatheter aortic valve implantations.* An annual median of 48.2 (IQR 29.1–105.2) transcatheter aortic valve implantations (TAVI) procedures per million people were performed in 2016, varying from <25 per million people in Egypt, Romania, Poland, and Turkey to >100 per million people in Denmark, France, Switzerland, and Germany (*Table 1*). There was significant correlation between rates of TAVI and GNI per capita (r = 0.92, P < 0.001) (*Figure 4*).

f. *Percutaneous mitral valve interventions.* Mitral valve repair, nearly always by the MitraClip system, was performed in a median 4.4 (IQR 2.7–6.6) patients per million people across participating countries, with >15 procedures per million people in Italy, Switzerland, and Germany but ≤7 procedures per million people in the remaining 10 countries (data unavailable: the Netherlands and Turkey; procedure unavailable: Egypt) (*Table 1*). A median of only 1.9 (IQR 1.3–2.5) mitral balloon valvuloplasty procedures per million people were performed in the 16 survey countries with Spain and Egypt reporting ≥5 procedures per million people (data unavailable: Belgium, Denmark, France, the Netherlands, Romania, and Turkey) (Supplementary material online, *Figure S2*).

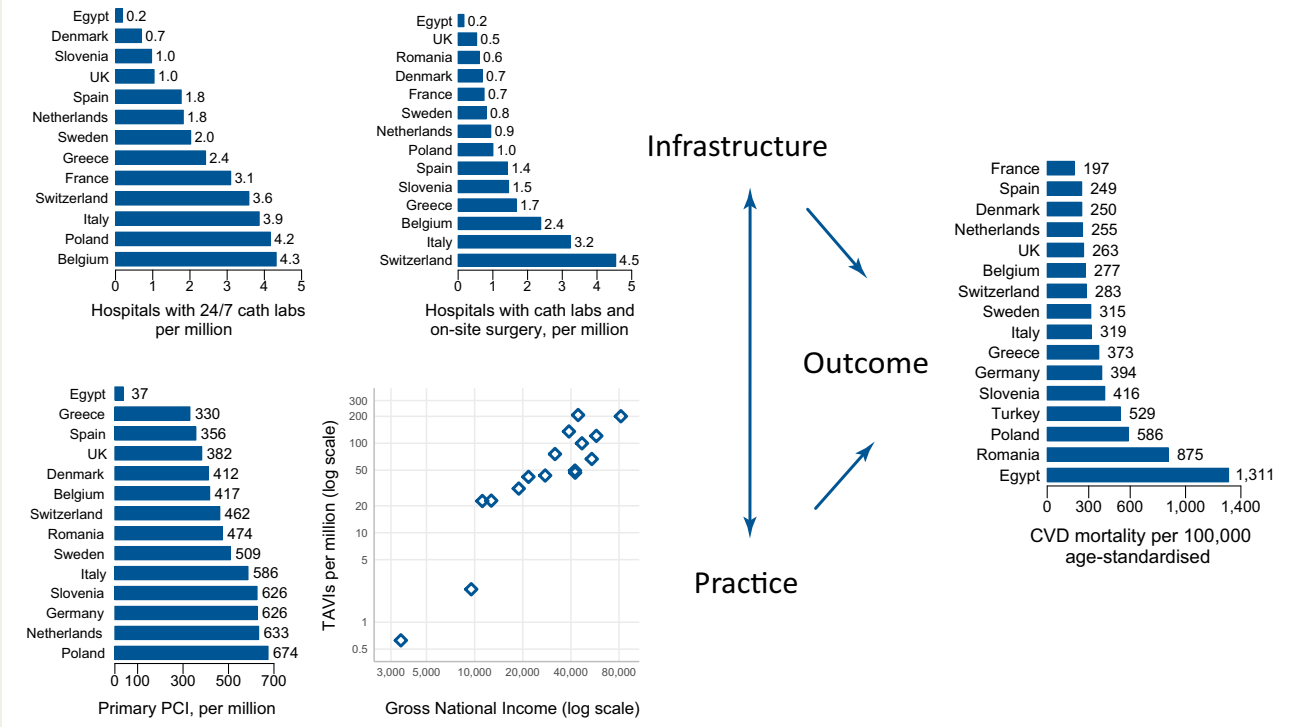
g. *Other percutaneous interventional procedures.* Atrial septum closure rates in 2016 were highly heterogeneous across participating countries, ranging from 3.1 procedures per million people in Egypt to 91.4 procedures per million people in Switzerland (data unavailable: Belgium, the Netherlands, Romania, and Turkey). Ventricular septal defect closures and left atrial appendage occlusions were reported in 6 and 12 participating countries, respectively, with Switzerland and Germany performing the most cases. Alcohol septal ablations were reported in nine participating countries, with Switzerland and Germany again performing most cases (Supplementary material online, *Figures S3–S6*).

National CVD mortality outcomes

Age-standardized CVD mortality across the 16 participating countries was 317 (IQR 261–444) per 100 000 people, ranging from <300 in Switzerland, the Netherlands, UK, Belgium, France, Spain, and Denmark to >800 in Egypt and Romania (*Table 1*). There was significant negative correlation between mortality and GNI per capita (r = –0.89, $P \leq 0.001$), diagnostic cardiac catheterizations (r = –0.63, P = 0.02) and PCI (r = –0.55, P = 0.03) per million people.

Discussion

The EAPCI Atlas of Interventional Cardiology survey was conducted in collaboration with the European Heart Agency with the aim of systematically mapping interventional cardiology practice in 16 ESC member countries. The data show considerable heterogeneity in interventional infrastructure, human resource, and procedure volumes. The heterogeneity we report showed association with national



Take home figure Crosstalk between clinical practice (bottom left), available infrastructure (upper left) and clinical outcomes (right) in the EAPCI Atlas Countries. PCI, percutaneous coronary intervention; TAVI, transcatheter aortic valve intervention; CVD, cardiovascular disease.

economic resource, a reflection no doubt of the technological costs of developing an interventional cardiology service.

Heterogeneity of interventional cardiology service provision was a key finding of this report and was reflected in the human resource statistics with 12-fold variation in interventional cardiologists per million people across the countries included in the survey. Infrastructure for service delivery showed similar variation, with Romania and Egypt, for example, reporting three to five times fewer catheterization laboratories per million people compared with better resourced countries such as Switzerland and Germany. Almost inevitably, therefore, rates of diagnostic heart procedures and PCIs in Romania and Egypt were substantially lower compared with Switzerland and Germany. Not only were interventional services under-resourced in Egypt but few of the hospitals in this country were equipped with catheterization laboratories that offered round-the-clock treatment of cardiac emergencies, ensuring vanishingly low rate of primary PCI, with similar under-performance extending to structural heart interventions.

The costs are substantial of developing and maintaining an interventional cardiology service that is responsive to the constant innovations that characterize this burgeoning field.[9,10] It is no surprise therefore that of the 16 countries we surveyed, the more prosperous high-income countries of western Europe, particularly France, Germany, and Switzerland often featured among those with the best developed interventional infrastructure and the greatest procedural activity in marked contrast to middle-income countries such as Egypt and Romania. Indeed, we found significant correlations between GNI per capita and rates of diagnostic cardiac catheterization, PCI and TAVI. Further evidence that interventional procedure rates are driven primarily by national income status was provided by the negative correlations of diagnostic cardiac catheterization and PCI with mortality which itself negatively correlates with GNI per capita.

Despite the striking associations of infrastructure, procedure rates and outcomes with GNI per capita, it is not possible to attribute all the heterogeneity we observed in interventional healthcare to national income status. Thus Turkey, like Egypt and Romania, is a middle-income country but had twice as many interventional cardiologists per million people as the UK, laid second only to Germany in the number of diagnostic heart procedures performed and was one of only five countries that reported >2600 PCIs per million people in 2016. In all these regards Turkey was an outlier that, despite the 3rd lowest GNI per capita among the countries we surveyed, had developed a capacity for coronary intervention that was as good if not better than some of the high-income countries of western Europe. Our data provide further examples of this disconnect between national prosperity and coronary interventional capacity with Denmark reporting just slightly more hospitals with catheter laboratories per million people than Romania while Greece reported more hospitals with catheter laboratories than either Switzerland or Sweden. Clearly therefore effective interventional healthcare delivery is not only dependent on available resource but also on policy decisions about the priority that should be given to the treatment of CVD.

These decisions are made almost exclusively at national level in some healthcare systems such as the UK where government control of funding ensured the relatively low procedure volumes recorded in the survey.

An example of how simple shifts in national policy can drive effective coronary interventional healthcare is provided by Poland where the development of primary PCI networks 5–10 years ago was associated with substantial reductions in mortality of patients with ST-segment elevation myocardial infarction.[11] This policy-driven approach to the management of ST-elevation myocardial infarction no doubt saved many lives and contributed to our finding that Poland performed more primary PCI procedures per million people than any of the 16 countries we surveyed. Poland was also one of only four countries that achieved the goal of >600 procedures per million set by EAPCI in its Stent-for-Life initiative.[2]

The heterogeneity in interventional healthcare that was a key finding of this report reflected variable under-provision of facilities, person-power, and interventional technology in the countries we surveyed. Certainly, there was little evidence that the level of service provision in individual countries was clinically driven. In the case of CVD, for example, which remains the most common cause of death across ESC member countries,[6] mortality was higher in middle-income countries where interventional activity was generally lower compared with high-income countries, a paradox enshrined in the inverse care law of Tudor Hart.[12] Only occasionally was there evidence of responsiveness to national disease prevalence in the provision of interventional cardiological care, with Egypt reporting rates of mitral balloon valvuloplasty that exceeded all other countries responding to our survey, a likely reflection of the continuing high prevalence of rheumatic heart disease in that country.[13]

In general, the development in recent years of structural heart interventions for treatment of valvular heart disease and septal defects has shown patchy uptake. Percutaneous TAVI is probably the intervention with the strongest evidence base[5,14,15] and implementation has been encouraged by the EAPCI Valve-for-Life initiative.[3] Transcatheter aortic valve implantation programmes have become established in all of the 16 countries included in our survey although procedure numbers showed huge variation with near perfect linear correlation with national GNI per capita. Other structural heart interventions were performed in small numbers, if at all, in most countries, with the wealthier countries of western Europe often the early adopters. Given continuing uncertainty about indications, it seems entirely appropriate that the expense of procedures such as percutaneous mitral valve repair and left atrial appendage occlusion should fall primarily on those high-income countries with the organizational framework necessary for proper evaluation of these new technologies.

Strengths and limitations

Strengths of this study are the independence of the EAPCI Atlas survey from commercial bias and its provision of national interventional statistics that are unavailable from other sources. Limitations include missing data, and although national infrastructure and human resource statistics were 100% complete, procedural statistics were only 84% complete, ranging from ≤75% for intracoronary imaging, mitral balloon valvuloplasty, and atrial septal defect closure to 100% for PCI and TAVI. Further limitations included uncertainty about the representativeness of participating countries with respect to ESC member countries and the precision of data estimates which in many countries were not available in national registries and were sourced as necessary by the National Societies. Any such imprecision was likely mitigated by the steps taken to ensure data quality. Last, we did not capture the procedures for atrial septum defect (ASD) and patent foramen ovale (PFO) closure, separately. Considering that prevalence of ASD is <1%, while that of PFO is about 25% of the general population, we can assume that large majority of atrial septum closures consist of PFO closures.[16,17] A statistically significant negative correlation was observed between mortality and rate of diagnostic cardiac catheterizations, as well as PCI per million people. Although this might suggest a link between coronary interventions and reduced mortality, the observational nature of our findings does not allow assumption of a causal relationship.

This is the first presentation of cardiac interventional statistics from the EAPCI Atlas survey. Furthermore, biennial data collections are planned with a view to eventual inclusion of all 57 ESC member countries. This will provide a stimulus for the establishment of national registries to document interventional infrastructure, procedure rates and, in the longer term, cardiovascular outcomes. Importantly, the inequalities in service provision highlighted in this report will provide a basis for international benchmarking and a stimulus for policymakers across ESC member countries to develop interventional programmes to match the best. This will require prioritizing budgetary allocations to CVD recognizing that it remains a major cause of disability and premature death.

Supplementary material

Supplementary material is available at *European Heart Journal* online.

Conflict of interest: E. Barbato reports personal fees from Boston Scientific and from Abbott Vascular; A. Baumbach reports personal fees from Astra Zeneca, KSH, Microport, Sinomed, and grants from Abbott Vascular; A. Banning reports personal fees from Boston Scientific, Abbott Vascular, Phillips Volcano, and grants from Boston Scientific; J. Legutko reports personal fees from Philips Volcano, Terumo, Balton, Bracco imaging, Medtronic, Abbott Vascular, Procardia; M. Pans reports personal fees from Abbott Vascular; G. Cayla reports personal fees from Amgen, Astra Zeneca, Bayer, Biotronik, Bristol Myers Squibb, Europa, MSD, Pfizer, Sanofi, personal fees and grants from Medtronic, grants from Fondation Coeur et Recherché; D. Vinereanu reports grants and personal fees from Astra Zeneca; O. Goktekin reports personal fees from Abbott, Medtronic, Boston Scientific, Terumo, Asahi; P. Vardas reports personal fees from Menarini International, Dean Medicus, Servier, European Society of Cardiology, Hygeia Hospitals Group. M Haude reports personal fees from Biotronik AG, Abbott Vascular, Cardiac Dimensions, Orbus Neich, and grants from Biotronik AG, Abbott Vascular, Cardiac Dimensions, Medtronic, Philips Volcano, Lilly. All the other authors have nothing to disclose.

Appendix

EAPCI Atlas manual. Definitions of the collected variables

Chapter 1. Health care resources with focus on interventional cardiology

(1) *Country population (millions):* Atlas.

(2) *Hospitals with catheterization laboratories:* Total number of hospitals, public or private, with one or more catheterization laboratories performing either diagnostic coronary angiographies or percutaneous coronary interventions (PCI), irrespective of whether the procedure occurs on an ambulatory basis or with overnight stay. If a hospital has more than one catheterization laboratory, it is counted as one.

(3) *Total catheterization laboratories:* Total number of catheterization laboratories, public or private, performing either diagnostic coronary angiographies or percutaneous cardiovascular interventions (e.g. PCI, TAVI). Please count the total number of labs, e.g. if a hospital has four catheterization laboratories the answer is four.

(4) *Hospitals with catheterization laboratories on 24 h/7 days service:* Total number of hospitals, public or private, with one or more catheterization laboratories performing urgent or primary PCI (pPCI) in patients with acute coronary syndromes (unstable angina, NSTEMI, STEMI) 24 h a day, 7 days a week.

(5) *Hospitals with catheterization laboratories and on-site cardiac surgery:* Total number of hospitals, public or private, with one or more catheterization laboratories performing either diagnostic coronary angiography or PCI, with an on-site cardiac surgery division. Please do not include the hospitals with remote surgery backup.

(6) *Hospitals with catheterization laboratories performing structural heart disease interventions in the adult:* Total number of hospitals, public or private, with one or more catheterization laboratories performing percutaneous transcatheter aortic valve implantations (TAVI), mitral and/or tricuspid valve interventions, left atrial appendage (LAA) closures, patent foramen ovale (PFO) closures, atrial ventricular defects (AVD) closures, or septal ventricular defects (SVD) closures, with or without on-site cardiac surgery.

(7) *Hospitals with catheterization laboratories performing TAVI:* Total number of hospitals, public or private, with one or more catheterization laboratories performing percutaneous TAVI, with or without on-site cardiac surgery.

(8) *Interventional cardiologists:* Total number of cardiologists able to perform as first operator either diagnostic coronary angiographies and/or percutaneous interventions.

(9) *Registry on interventional cardiology practice:* If one or more national registries exist collecting data on interventional cardiology (IC) practice, please describe:
   a. the number of these national registries with related starting date;
   b. whether the registry is overarching (e.g. dedicated to the IC practice in general) or focused on a particular topic (e.g. dedicated to STEMI only, or to vascular scaffolds, etc.);
   c. whether there is a quality control of the data included in the registry(ies) and how this quality control is performed;
   d. whether the registry(ies) has(ve) a website (in which case provide the URL);
   e. what are the governance arrangements for the registry (e.g. ownership of the data, who is responsible for the registry, etc.).
   f. % of hospitals with catheterization laboratories included in the registry(ies).

(10) *Working group of interventional cardiology website:* Provide the URL if a website of the interventional working group is available.

(11) *Reimbursement policies of the interventional procedures:* Describe the method of reimbursement for:
   a. PCI either with balloon only or with stenting.
   b. Adjunctive intracoronary imaging (IVUS, OCT, etc.) or physiology devices (flow or pressure wires, etc.).
   c. Percutaneous valve interventions.
   d. Adult structural heart disease interventions (PFO, ASD, VSD, LAA closures, etc.).

Chapter 2. Procedures and resources for coronary interventions

This section aims to collect data on the number and type of coronary procedures as well as on the resources and equipment used as provided by the European Working Groups of Interventional Cardiology.

(1) *Diagnostic heart procedures:* Total annual number of coronary angiographies and/or diagnostic (left and/or right) heart catheterization.

(2) *PCI:* Total number of coronary interventions including balloon angioplasties, with stent or scaffold implantation, including procedures that use coronary ablation techniques, etc.

(3) *Per cent of PCI performed by trans-radial access.*

(4) *Primary percutaneozus coronary interventions (pPCI):* Total number of coronary interventions performed as first reperfusion therapy in patients with ST-elevation myocardial infarction (STEMI).

(5) *PCI in coronary with chronic total occlusions:* Total number of coronary interventions performed in coronary artery chronically ccluded (for more than 3 months either angiographically documented or clinically suspected) both with antegrade or retrograde approach.

(6) *PCI in left main (LM) coronary artery:* Total number of coronary interventions performed in 'unprotected' LM.

(7) *PCI for in-stent restenosis*: Total number of any coronary interventions in previously stented coronary segments.

(8) *PCI without stent:* Total number of coronary interventions without final stent and/or scaffold implantation.

(9) *PCI with drug-eluting balloons:* Total number of coronary interventions performed with the use of any kind of drug-eluting balloon.

(10) *Coronary stents:* Total number of coronary metallic stents implanted.

(11) *Coronary drug-eluting stents:* Total number of coronary metallic drug-eluting stents implanted.

(12) *Coronary bio-resorbable vascular scaffolds:* Total number of coronary bio-resorbable vascular scaffolds (polymeric or metallic) implanted.

(13) *Adjunctive intracoronary imaging techniques:* Total number of overall coronary procedures (coronary angiography and PCI) performed with either intravascular ultrasound (IVUS), optical coherence tomography (OCT or OFDI), near infrared spectroscopy (NIRS), etc.

(14) *PCI performed with adjunctive intracoronary imaging techniques:* Total number of PCI performed with either intravascular ultrasound (IVUS), optical coherence tomography (OCT or OFDI), near infrared spectroscopy (NIRS), etc.

(15) *Adjunctive intracoronary physiology measurements:* Total number of overall coronary procedures (coronary angiography and PCI) performed with either coronary flow reserve (CFR), fractional flow reserve (FFR), instantaneous wave free ratio (iFR), etc.

(16) *PCI performed with adjunctive intracoronary physiology measurements:* Total number of PCI performed with either CFR, FFR, iFR, etc.

(17) *PCI with rotational or orbital atherectomy:* Total number of PCI performed with adjunctive rotational or orbital atherectomy.

(18) *Use of hemodynamic support devices:* Total number of coronary angiographies or PCI performed in the catheterization laboratory with haemodynamic support devices like intra-aortic balloon pump (IABP), Impella, etc.

Chapter 3. Procedures and resources for structural heart interventions

This section aims at collecting data on the number and type of percutaneous valve and heart procedures performed in adults and also data on the resources and equipment used, as provided by the European Working Groups of Interventional Cardiology.

(1) *Alcohol septum ablations:* Total number of percutaneous alcohol myocardial septum ablation performed in adult patients with left ventricular hypertrophy.

(2) *Mitral balloon valvuloplasties:* Total number of percutaneous mitral valve balloon dilatation performed in adult patients with mitral stenosis.

(3) *Mitral valve repairs:* Total number of percutaneous mitral valve repair procedures in adult patients with mitral regurgitation (e.g. Mitraclip, valve in prosthesis/ring, etc.).

(4) *Aortic balloon valvuloplasties:* Total number of percutaneous aortic valve balloon dilatation performed in adult patients.

(5) *TAVI:* Total number of transcatheter aortic valve implantations (trans-vascular and trans-apical) performed in adult patients.

(6) *Percutaneous TAVI (pTAVI):* Total number of percutaneous `vascular aortic valve implantations performed in adult patients.

(7) *Peri-valvular leaks closures:* Total number of percutaneous procedures with closing device implantation in peri-valvular prosthesis leaks.

(8) *Valve-in-valve percutaneous implantations:* Total number of percutaneous TAVI in patients with previous aortic bio-prosthesis (valve-in-valve) or with previous mitral valve ring (valve-in-ring).

(9) *Procedure with cerebral embolic protection devices:* Total number of percutaneous procedures (e.g. TAVI, etc.) performed with cerebral embolic protection devices.

(10) *Atrial septum closures:* Total number of percutaneous procedures performed in adult patients aiming at closing atrial septum defects, like PFO or atrial septum defect (ASD).

(11) *Ventricular septum closures:* Total number of percutaneous procedures performed in adult patients aiming at closing ventricular septum defects (VSD).

(12) *LAA occlusions:* Total number of percutaneous procedures performed in adult patients aiming at occluding LAA.

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