Cardiac rehabilitation availability and delivery in Europe: how does it differ by region and compare with other high-income countries? Endorsed by the European Association of Preventive Cardiology.

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Cardiac Rehabilitation Availability and Delivery in Europe: How does it Differ by Region and Compare to other High-Income Countries? Endorsed by European Association of Preventive Cardiology

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Abstract Aims

To establish: (1a) CR availability and density, as well as (1b) the nature of programs, and (2) compare these (a) by European region (geoscheme) and (b) to other high-income countries (HICs).

Methods

A survey was administered to CR programs globally. Cardiac associations were engaged to facilitate program identification. Density was computed using Global Burden of Disease study ischemic heart disease (IHD) incidence estimates. Four HICs were selected for comparison (N=790 programs) to European data, and multi-level analyses performed.

Results

CR was available in 40/44 (90.9%) European countries. Data were collected in 37 (94.8% country response rate). 455/1538 (29.6% response rate) program respondents initiated the survey. Program volumes (median=300) were greatest in Western European countries, but overall were higher than other HICs ($p<.001$). Across all Europe, there was on average only 1 CR spot per 7 IHD patients, with an unmet regional need of 3,449,460 spots annually. Most programs were funded by social security (n=25, 59.5%; with significant regional variation, $p<0.001$), but in 72 (16.0%) patients paid some or all of program costs (or ~ 18.5% of the ~€150.0/program) out-of-pocket. Guideline-indicated conditions were accepted in ≥70% of programs (lower for stable coronary disease), with no regional variation. Programs had a multidisciplinary team of 6.5±3.0 staff (number and type varied regionally; and European programs had more staff than other HICs), offering 8.5±1.5/10 core components (consistent with other HICs) over 24.8±26.0 hours (regional differences, $p<0.05$).

Conclusion

European CR capacity must be augmented. Where available, services were consistent with guidelines, but varied regionally.

Keywords: Cardiac Rehabilitation; Europe; Survey

Introduction

Similar to other high-income countries (HICs), cardiovascular diseases (CVD) are among the leading burdens of disease and disability in Europe[1,2]. Accordingly, it is the most expensive health condition to treat in terms of direct and indirect costs[2]; overall CVD is estimated to cost the EU economy €210 billion a year [2]. CVD is a chronic condition, and hence secondary prevention is key to managing this massive burden on the healthcare system, as well as on patients and their families.

Cardiac rehabilitation (CR) is an established model of care for secondary prevention, which is cost-effective, affordable, and averts costly downstream healthcare utilization[3]. Based on substantive evidence that participation is associated also with 20% reductions in cardiovascular mortality and morbidity[4,5] clinical practice guidelines[6] for CVD revascularization and heart failure patients, among others, recommend referral to CR. Many European countries have CR guidelines[7–16], as does the European Association of Preventive Cardiology[6], a branch of the European Society of Cardiology, which specify the core components (e.g., initial assessment, structured exercise training, and risk factor management, including stress) which are to be delivered by a multi-disciplinary team of healthcare professionals with expertise in all the secondary prevention recommendations[17]. It is recommended programs offer a minimum dose of 12 sessions, although greater benefits could be achieved with more[18], and these sessions can be delivered in an unsupervised setting if patients have barriers to participation[19].

The availability and nature of CR in European countries has been described following 2 previous surveys of national coordinators[20,21]. There have also been surveys of individual programs in Denmark[22], Italy[23], Portugal[24–26], Spain[27] and the United Kingdom[28–33], but this is only 5 of the approximately 44 countries in Europe. These surveys did characterize funding sources, volumes, CR dose, healthcare providers on CR teams, accepted indications, core components delivered, and delivery of alternative models (for a summary see Pesah et al.[34]). However, little is known about the capacity and density of CR. Moreover, assessment of individual programs across European countries with the same assessment tool has never been undertaken to enable comparison against the above guideline recommendations across the region, nor has there been any assessment and comparison of services with any other region in the world[34].

Accordingly, the objectives of this investigation were to: (1) characterize the availability, volumes, capacity and density of CR (a) by European country, (c) region, and (c) in relation to other HICs; (2) characterize the following aspects of CR: (a) who pays for services and costs, (b) type of patients served, (c) number and types of healthcare professionals on the CR team, (d) number of program sessions / dose, (e) core components delivered, and (f) delivery of alternative models, again by European country, region, and in comparison to other HICs.

Methodology

Design & Procedure

This research was cross-sectional in design; detailed methods are reported elsewhere (Supervia et al., under review). In brief, countries where CR services were available were identified first through previous reviews[35,36]. In countries where CR services were not suspected to be available, the internet was searched and major CR and cardiology societies were contacted to identify any programs or verify lack thereof.

For each country identified to offer CR, first available CR or cardiac society leadership were contacted (e.g., European Association of Preventive Cardiology). If there was no society available or response, "champions" were identified, and in the case of European countries, the European Society of Cardiology national CVD coordinators were contacted. Identified leaders were sent an e-mail requesting their collaboration to:
(a) determine the number of programs in their country, and (b) assist with administration of the survey to each program in their country.

Each identified program was emailed with the request to complete the survey. Informed consent was secured through an online form. The survey was administered through REDCap, with data collection occurring from June 2016 to December 2017.

Sample

For the global study, the sample consisted of all CR programs identified in the world that offer services to patients following an acute cardiac event or hospitalization (i.e., Phase II). The inclusion criteria were CR programs that offered: (1) initial assessment,
(2) structured exercise, and (3) at least one other strategy to control CV risk factors.

For the purposes of this study, CR programs in European countries (according to the geoscheme regions[37]; small islands and jurisdictions were excluded, e.g., Aland islands, Vatican City) as well as in 4 other HICs (United States, Canada, Australia and New Zealand; i.e., countries most comparable to European HICs) were selected.

Measures

With regard to the first objective, CR availability referred to existence of ≥1 program in a country. Program volume was defined as the median number of patients served by a program annually (program-reported in survey, described below). National and regional CR capacity were computed by multiplying the median number of patients a program could serve annually (program-reported in survey) among the responding programs in a given country or region respectively, multiplied by the total number of programs in that jurisdiction (ascertained from literature and/or champion). Please note for countries where no surveys were completed, capacity was computed by multiplying the number of programs by median regional program volumes. Lastly, to compute density, ischemic heart disease (IHD) incidence was pulled from the Global Burden of Disease study[38]. Then, the ratio of capacity (as computed above) per annual incident IHD case was computed. Unmet need was computed as IHD incidence minus national capacity.

Development of the survey is described in detail elsewhere[39]. In short, items were based on previous national/regional CR programs surveys[20,40]. Most items had forced-choice response options, and skip-logic was used to obtain more detail where applicable. The survey is available elsewhere (Supervia et al., under review).

The following variables were assessed: (i) who funds the program (i.e., private sources such as healthcare insurance, public sources such as government, or a combination of these sources [i.e., hybrid]), (ii) the type (e.g., myocardial infarction, as well as non-cardiac indications) and number of patients served per session (as well as staff-to-patient ratio), (iii) the number and types of healthcare professionals on the CR team (part-time staff were counted as 0.5), (iv) dose of CR (in hours; i.e., sessions per week x duration in weeks x duration of exercise sessions in minutes/60); (v) the type and number of core components delivered (of 10; i.e., initial assessment [including risk factors assessed and type of functional capacity test], risk stratification, structured exercise, patient education, risk factor management, nutrition counselling, stress management, smoking cessation interventions, prescription or titration of medication, and communication with a primary healthcare provider), and (vi) whether the program offers alternative CR models (i.e., home or community-based programs, or hybrid models where patients transition from supervised to unsupervised settings).

Data analysis

SPSS version 24 was used for analysis[41]. All initiated surveys were included. The number of responses for each question varied due to missing data (e.g., respondent did not answer a question due to lack of willingness or potential inapplicability, use of skip logic); for descriptive analyses, percentages were computed with the denominator being the number of responses for a specific item. Descriptive statistics were used to characterize availability, volume, capacity, density, as well other closed-ended items in the survey (e.g., funding sources, healthcare professionals on the CR team, and core components delivered).

All open-ended responses were coded / categorized. Aspects of CR were then compared by nationally, regionally and versus other HICs using generalized linear mixed models to take into consideration the hierarchical nature of data (e.g., CR programs nested within countries) where applicable and there were sufficient data in each country for estimates to be generated. Otherwise ANOVA or chi-square tests were applied.

Results

As shown in Table 1, CR is available in 40 (90.9%) of the 44 European countries. Data were collected in 37 (92.5%) countries. Of these, 8 (Belarus, Bosnia and Herzegovina, Bulgaria Romania, Russia, Moldova, Republic of Northern Macedonia and Serbia) were not considered high-income as per the World Bank[42]. No response was obtained from: Montenegro, Norway and Luxembourg (Figure 1).

In terms of programs, 455/1538 responded in Europe (29.6%; Table 1). Please note a subsample of programs only was surveyed in Austria and Scotland (1-2 programs per health board/region for the latter) due to champion preference. Of the 4 HICs selected for

comparison that had CR, 234 surveys were initiated (30.1% response rate).

Volumes, Capacity and Density

The number of programs per country and region is shown in Table 1. Of responding programs, 287 (65.9%) reported being situated in an urban area, and 83 (19.1%) in a suburban area. Overall, 337 (78.9%) were in a hospital (academic, community or rehabilitation); of which 155 (45.9%) were academic or tertiary centres. Two hundred and four (51.1%) programs reported that there was another CR program within a 20km radius (vs. 87 [38.7%] in other HICs).

Volumes, capacity and density are shown in Supplemental Table 1. Volumes per program (median=300) were greatest in Western Europe (median=515). Program volumes were significantly higher than in other HICs ($p<0.001$). Median national capacity was 4170 CR spots/country (7563 for Northern, 3000 for Eastern, 2300 for Southern and 27450 for Western). It was significantly higher than the other HICs.

Overall European density was 1 spot per a median of 7 IHD patients / year / country (per 2 for Northern countries, 21 for Eastern, 13 for Southern and per 4 patients for Western region; Supplemental Table 1). In other HICs, the density was on average 1 spot for 2 patients. As shown in Table 1, unmet CR need was substantially higher in Eastern Europe, particularly due to the dearth of CR in Russia.

Nature of CR Services

Program responders were asked to report who pays for their services, and could check all applicable sources (n=112, 25.7% reported >1 source; Table 2). Overall, 312 (69.5%) programs reported government funding ($p=0.11$ for regional variation), 115 (25.6%) reported hospital / clinical centre funding (with significant regional variation, $p=0.001$), 77 (17.1%) reported private health insurance ($p<0.01$), and 72 (16.0%) reported the patient pays ($p=0.15$). Funding source in Europe was not different than other HICs ($p=0.50$).

In 15 (3.3%) programs, the sole source of funding was the patient ($p<0.001$; data shown by country elsewhere[43]). Table 2 also displays the proportion of the total program cost patients pay when they are a source of CR financing, and the associated estimated cost to them (purchasing power parity values by country shown elsewhere[43]). Direct cost to patient differed between regions where they paid ($p<0.05$), with the Southern region having the highest cost (€809.21). The estimated cost to deliver a full course of CR (as per dose shown in Figure 2) is also shown; cost differed between regions ($p<0.001$), with the Western and Southern region having the highest cost (€2,163 and €3,090). There was also no difference from other HICs for cost to deliver a full course of CR ($p>.05$).

The most common type of patients accepted in CR programs are shown in Table 3 (shown by country in Supervia, M. et al., under review). There was significant regional variation for heart failure (accepted less often in Southern Europe), and the only significant difference between European HICs and other HICs was for valve procedures (accepted more often in European HICs).

Other accepted indications included: heart transplant (n=282, 63.8%), congenital heart disease (n=266, 60.2%), patients with techanical circulatory support devices (n=188, 42.5%) and implanted devices for rhythm control (n=187, 42.3%). Many programs also accepted patients with non-cardiac indications, namely: intermittent claudication / peripheral vascular disease (n=149, 33.7%), diabetes (n=122, 27.6%), lung disease (n=103, 23.3%), stroke (n=74, 16.7%) and cancer (n=50, 11.3%).

The number and nature of healthcare professionals on CR teams is shown in Table 4 (shown by country in Supervia, M. et al., under review); programs on average had 6.5 staff members, most commonly a nurse, physiotherapist, cardiologist, dietitian and administrative assistant. There was significant regional variation in total number

(higher in west than north), and type (i.e., fewer cardiologists [among other physicians], psychologists and administrative assistants in north) of providers. When compared to other HICs, Europe had significantly more staff overall, with more physiotherapists, cardiologists, physiatrists, and sports medicine physicians as well as psychologists and psychiatrists on their CR teams.

During exercise sessions, there was most commonly a physiotherapist (n=248, 82.7%) and a nurse (n=184, 63.2%) present. The median number of patients per supervised exercise session was 9 (Q25-Q75=6-12). The overall dose of CR was 24.8±26.0 hours (median=16.0; Figure 2; median frequency was 2.5 sessions per week, and program duration was 8.0 weeks). There was significant variation by region ($p<0.05$), with higher doses in the Southern and Western regions. Dose was not significantly different in Europe than other HICs.

Programs offered 8.5/11 "core" components on average (Table 5; shown by country in Supervia, M. et al., under review), this did not vary significantly by region. There was some significant regional variation in provision of return-to-work counselling (higher in west), among some other elements. There were some significant differences in delivery of components in European versus other HICs (but the same number offered overall), namely counselling for return-to-work, prescription and /or titration of medications and functional capacity testing (by multiple means) were more frequently delivered in European HICs. Risk factors assessed pre-program, and equipment to deliver components are reported elsewhere by country (Supervia, M. et al., under review).

Finally, alternative CR model delivery is shown in Figure 1; 119 (33.5%) programs reported delivery of any alternative model (more detail on type is shown in Ghisi, G. et al.[44]). Twenty-five (21.0% of programs that offered alternative models, or 5.5% of all programs) programs reported using smartphones, an "app", or text messaging with patients (i.e., some form of eCR). There was significant variation by region ($p<.05$), but there was not significantly different alternative model implementation when compared to other HICs ($p>.05$).

Discussion

For the first time, the unmet need for CR has been estimated in Europe, with well over 3 million more spots needed per year to treat IHD patients alone, and the grossest unmet need in Eastern Europe. Where available, countries have a median of 16 programs each treating 300 patients (with guideline-indicated conditions accepted in ≥85% of programs, but stable coronary disease less so)

per year. Government is the most common CR funding source for programs that cost a mean of ~€1850, but in approximately 40% of programs patients are paying out-of-pocket (for 35% of the program cost or ~€500/patient/program). Patients are prescribed a median of 16 hours of CR (which is considered sufficient to achieve the benefits)[18], covering a median of 8.5 core components (with significant variation in delivery of return-to-work counselling needing to be addressed, and more consistent delivery of tobacco cessation interventions needed as well) delivered by 6.5 staff (with the type differing by region and varying from the composition in other HICs).

No study has ever attempted to quantify density and unmet need in Europe, so this is a first and best attempt. The overall value for unmet need does not take into consideration patients who may have contraindications to participation (not to exercise as patients should receive the other core components), or heart failure patients who are also indicated, so more research is needed. While we did not compute unmet need in all global regions, when comparing density of CR in other regions (only considering countries with CR) of the globe, Europe and the Western Pacific have the best and quite comparable density, with Africa the worst.

Moreover, this is the first ever survey of all CR programs in Europe (although the European Society of Preventive Cardiology has recently re-surveyed national coordinators [but not individual programs][45], and so we look forward to those results becoming available). Results are fairly consistent with the previous surveys of programs in Europe[34], with regard to funding source, accepted indications, most common healthcare providers, dose, as well as the low availability of CR in alternative settings.

The implications of this work are many. Policy recommendations include advocacy for better reimbursement of CR services by public sources and private healthcare insurance so patients are not paying out-of-pocket[46]. Recommendations to augment capacity include initiating services in countries without CR, and expanding provision of eCR[47,48], particularly in Russia, Belarus and Greece where unmet need is greatest. Program-level innovations recommended on the basis of this work include more consistent provision of return-to-work counselling to optimize life functioning for patients and reduce the negative impacts of CVD on the economy. Moreover, given tobacco cessation is the most impactful change for secondary prevention[49], clearly universal delivery should be pursued. Indeed, results from EUROASPIRE IV demonstrate that CR participants are not quitting tobacco at a rate greater than non-participants[50], bolstering our call for more focus on this component in European CR programs.

In terms of directions for future research, there are several important avenues to be pursued. First, while the survey assessed structure and process indicators of CR programs, how these translate to patient outcomes cannot be ascertained. Field tests of CR programs, examining the "how" and what is delivered in each core component, and in non-supervised settings is warranted, as well as actual dose received by patients (i.e., adherence to prescribed sessions). Europe did have a multinational registry[51], and it would be ideal to link this structural program data to the patient-level data in a registry to determine the degree of quality of CR in Europe. Given there are other countries that also have registries[52], again CR delivery in Europe could be benchmarked against these other countries.

This study has several limitations. First, there may be ascertainment bias or under-estimation of capacity due to failure to identify programs or differences in the nature of programs identified to those that may have not been identified. Second, response rates to online surveys are notoriously low. The country response rate was high, but the program rate was 30% in the current study, which is fair, but suggests there may be bias (potentially higher-quality programs are better-represented). Third, respondents may have been inclined to respond in a socially-desirable manner, such that results were skewed to reflect better provision of CR. However, participants were informed that their responses were confidential. The recent data from EUROASPIRE IV does suggest that provision of some CR components is insufficient to achieve target risk reductions[50]. Fourth, CR in Europe was compared to only four other HICs; comparisons to other HICs in future could provide useful information. Finally, multiple comparisons were performed, and there were few respondents in some countries, and hence caution is necessary when interpreting the findings.

Conclusion

There are 1500 CR programs across Europe, existing in ~90% of countries. However, there is only one spot for every 7 patients in need (with particularly great need for capacity increases in Eastern Europe), although this density is quite good compared to other regions of the globe. Program delivery is highly consistent with European CR guidelines, although there is significant regional variation in relation to funding sources, costs to patients, the nature of providers on CR teams, dose and alternative model delivery. Moreover, the nature of services is quite consistent with that in other comparable HICs, except in terms of program volumes, the number and nature of providers on CR teams and the type of core components offered.

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Conflict of Interest
None declared

Authors' Contributions
MS, KTA, SLG, FLJ, BB-W contributed to the conception or design of the work. EP, MS, KTA, AA, MA, KA, VG, DV, EV, DG, JC, EK, IY, SA, AH, ET, HK, ZE, SF, JH, EP, SD, BP, AK, AND ES contributed to the acquisition, analysis, or interpretation of data for the work. AA, EP and SLG drafted the manuscript. AA critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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Figure 1. Delivery of alternative cardiac rehabilitation models* by European country. *Home-based (including eCR), ...

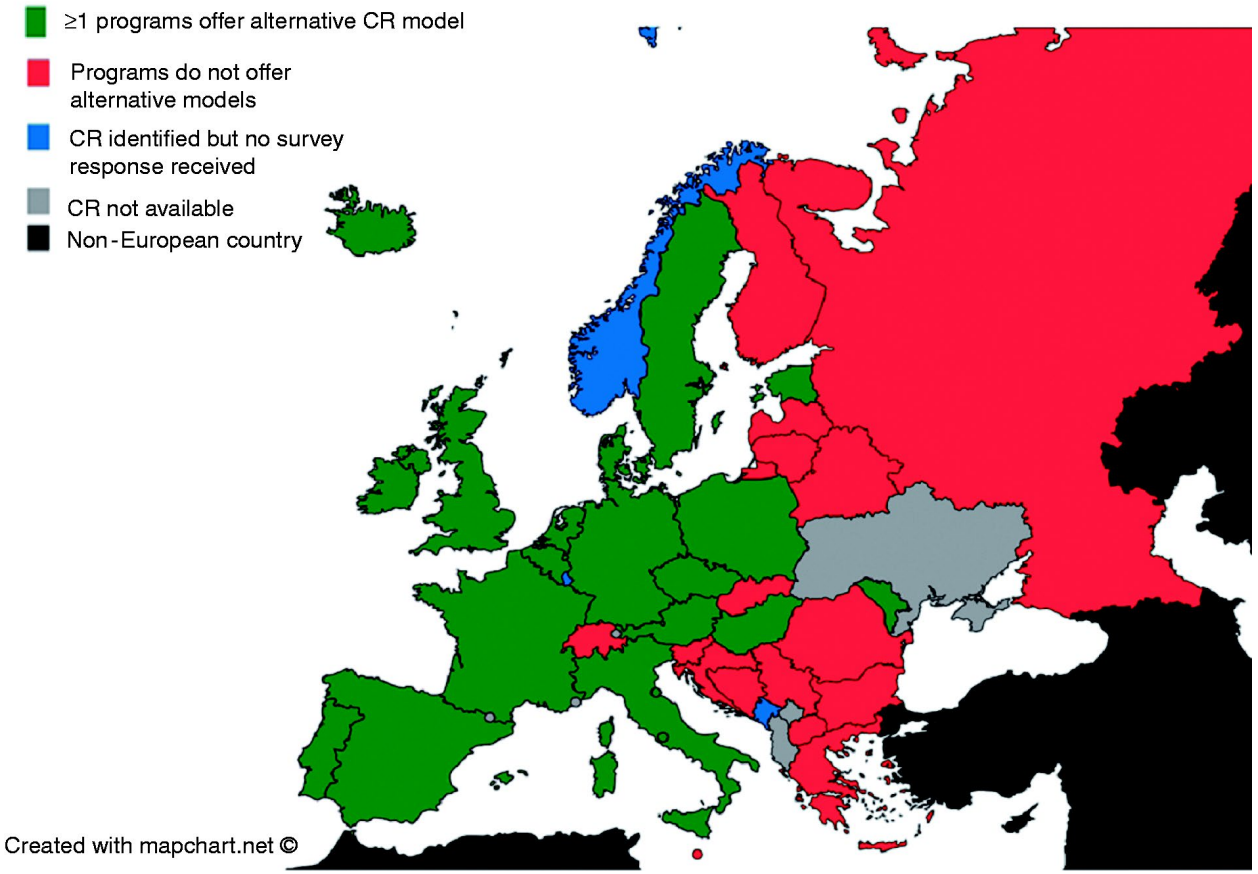

Figure 1. Delivery of alternative cardiac rehabilitation models* by European country. *Home-based (including eCR), community-based or hybrid (i.e. supervised transitioning to unsupervised setting). CR: cardiac rehabilitation. ‘Take-home figure’.

Figure 2. Mean cardiac rehabilitation dose (hours/programme), by European country* versus other high-income countries. ...

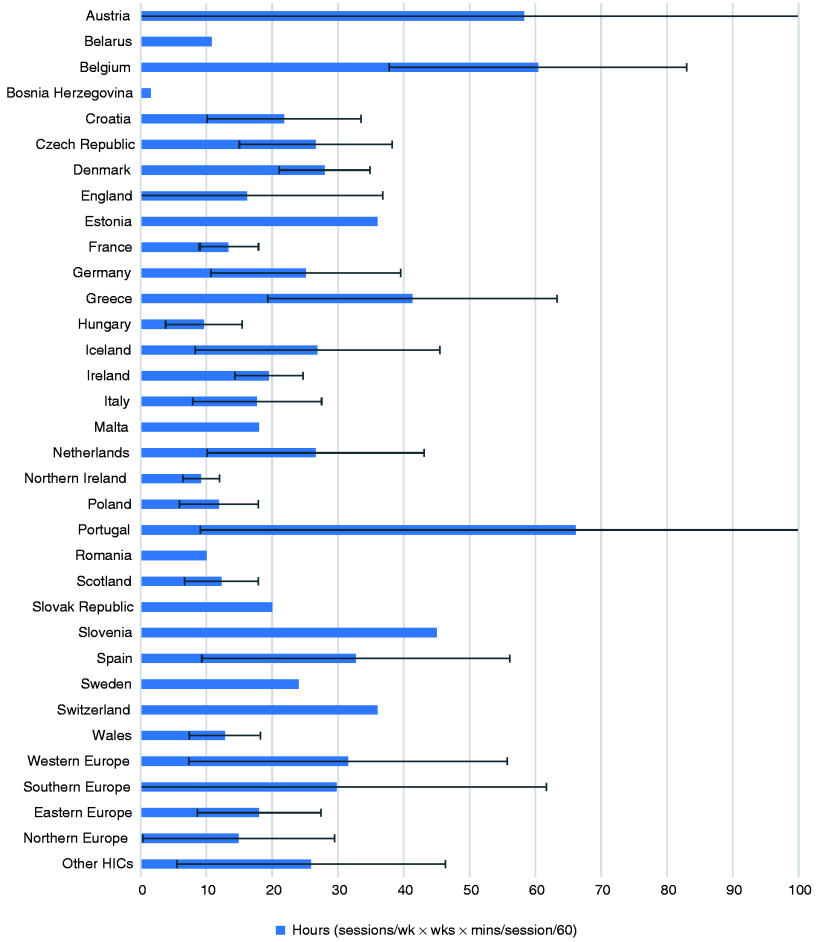

Figure 2. Mean cardiac rehabilitation dose (hours/programme), by European country versus other high-income countries. *Insufficient information to compute dose (i.e. frequency, programme duration, or session duration were not reported) for the following countries: Finland, Latvia, Lithuania, Bulgaria, Moldova, Russia, Republic of Northern Macedonia, and Serbia. HIC: high-income country. Whiskers denote standard deviation. Where missing, n = 1. Note: Dose significantly differed by region: $P < 0.05$.*

Table 1.

European countries, number of programmes per country, programme response rate and unmet need.

	Number of programmes	Number of responses	Programme response rate (%)	Unmet need[a]
Northern Europe				
Denmark	35	8	22.9%	14,705
England	266	57	21.40%	185,284
Estonia	2	2	100.0%	10,638
Finland	25	11	44.0%	23,227
Iceland	4	4	100.0%	830
Ireland	37	7	18.9%	4900
Latvia	2	1	50.0%	13,943
Lithuania	25	9	36.0%	0
Northern Ireland	13	10	76.90%	6016
Norway	35	0	0.0%	2072
Scotland[c]	69	24	34.8%	9785[b]
Sweden	69	1	1.4%	40,125
Wales	17	16	94.1%	9057
Subtotal (across 12/13 countries with CR; 92.3%)	599	150	25.0%	293,878

Eastern Europe				
Belarus	5	1	20.0%	87,374
Bulgaria	1	1	100.0%	52,871
Czech Republic	15	6	40.0%	63,012
Hungary	33	20	60.6%	50,558
Poland	56	21	37.5%	216,460
Republic Moldova	1	1	100.0%	20,976
Romania	3	2	66.7%	119,335
Russian Federation	3	3	100.0%	1,222,142
Slovak Republic	7	1	14.3%	28,036
Subtotal (across 9/9 countries with CR; 100%)	124	56	45.2%	1,860,764
Southern Europe				
Bosnia Herzegovina	1	1	100.0%	17,068
Croatia	3	3	100.0%	23,246
Greece	4	4	100.0%	60,636
Italy	221	70	31.7%	280,771
Republic of Northern Macedonia	1	1	100.0%	8285
Malta	1	1	100.0%	1058
Montenegro	1	0	0.0%	2674

Portugal	23	21	91.3%	33,584
Serbia	2	2	100.0%	37,125
Slovenia	2	2	100.0%	10,835
Spain	87	47	54.0%	165,097
Subtotal (across 10/11 countries with CR; 90.9%)	346	152	43.9%	640,754
Western Europe				
Austria[c]	26	5	19.2%	27,701
Belgium	48	9	18.8%	52,585
France	130	16	12.3%	196,201
Germany	120	34	28.3%	286,474
Luxembourg	4	0	0.0%	183
Netherlands	90	29	32.2%	48,050
Switzerland	51	4	7.8%	16,541
Subtotal (across 6/7 countries with CR; 85.7%)	469	97	20.7%	629,235
Total (across 37/40 European Countries with CR; 92.5%)	1538	455	29.6%	3,449,460

a Annual ischaemic heart disease incidence from global burden of disease study[51] estimates minus number of CR spots per year (i.e. national capacity, calculated as median number of patient programmes could serve per year (from survey responses in given country) multiplied by the number of programmes in the country (ascertained from literature or national champions); see online supplement and Turk-Adawi et al. under review).

b Value estimated as respondents provided capacity by region, not programme. If we roughly multiply the 24 regions by 850 patients served per region, national capacity could be 20,400. Thus, unmet need could be approximately 9785. [c]Sub-sample surveyed only, and therefore response rates actually higher (e.g., for Scotland the lead of each health region was surveyed, and there was a 100% response).

CR: cardiac rehabilitation; NA: not available.

Table 2.

Cardiac rehabilitation financing and costs.[a]

	Most frequent funder (*n*, %)[b]	Proportion of programme cost patient pays (%)[c]	Direct cost to patient (2016 Euros)	Cost to deliver CR to 1 patient[d] (2016 Euros)
Northern Europe				
Denmark	Public (*n* = 8, 100.0%)	NA	NA	€1006.7 ± 1423.7
England	Public (*n* = 50, 87.7%)	66.5 ± 47.4	€63.3 ± 85.6	€579.3 ± 174.2
Estonia	Public (*n* = 2, 100.0%)	NA	NA	€520.0 ± 0.0
Finland	Public (*n* = 11, 100.0%)	NA	NA	€906.9 ± 824.1
Iceland	Hybrid (*n* = 2, 50.0%)	56.0 ± 26.5	€244.1 ± 246.4	€2131.8 ± 3098.1
Ireland	Public (*n* = 6, 100.0%)	NA	NA	€500.0 ± 0.0
Latvia	Hybrid (*n* = 1, 100.0%)	13.0 ± 0.0	€130.0 ± 0.0	€1040.0 ± 0.0
Lithuania	Public (*n* = 9, 100.0%)	NA	NA	€634.3 ± 211.6
Northern Ireland	Public (*n* = 10, 100.0%)	NA	NA	€680.6 ± 0.0

Scotland	Public (*n* = 22, 95.7%)	60.0 ± 0.0	NR	€616.5 ± 397.7
Sweden	Public (*n* = 1, 100.0%)	NA	NA	NR
Wales	Public (*n* = 14, 93.3%)	NR	€28.4 ± 0.0	€794.0 ± 0.0
Regional average	Public (*n* = 134, 91.1%)	53.4 ± 30.8	€145.3 ± 175.8	€821.7 ± 1025.6
Median (Q25–Q75)	NA	50.0 (33.0–85.0)	€123.8 (2.8–239.0)	€571.3 (484.9–788.0)
Eastern Europe				
Belarus	Public (*n* = 1, 100.0%)	NA	NA	€1500.0 ± 0.0
Bulgaria	Public (*n* = 1, 100.0%)	NA	NA	NR
Czech Republic	Public (*n* = 5, 83.3%)	50.0 ± 0.00	€97.2 ± 0.0	€1827.8 ± 0.0
Hungary	Public (*n* = 20, 100.0%)	NA	NA	€668.3 ± 153.3
Poland	Public (*n* = 20, 100.0%)	NA	NA	
Republic Moldova	Public (*n* = 1, 100.0%)	NA	NA	€354.2 ± 0.0
Romania	Public (*n* = 1, 50.0%)	NR	NR	€400.0 ± 0.0

Russian Federation	Public (*n* = 2, 66.7%)	NR	NR	NR
Slovak Republic	Private (n = 1, 100.0%)	95.0 ± 0.0	€180.0 ± 0.0	€180.0 ± 0.0
Regional average	Public (*n* = 51, 92.7%)	72.5 ± 31.8	€138.6 ± 58.6	€730.6 ± 426.7
Median (Q25–Q75)	NA	72.5 (50.0–2.5)	€138.6 (97.2–138.6)	€653.9 (396.4–933.8)
Southern Europe				
Bosnia Herzegovina	Hybrid (*n* = 1, 100.0%)	20.0 ± 0.00	€61.4 ± 0.0	€306.8 ± 0.0
Croatia	Public (*n* = 2, 66.7%)	17.0 ± 0.0	€268.0 ± 0.0	€1264.0 ± 577.6
Greece	Public (*n* = 2, 50.0%)	100.0 ± 0.0	NR	NR
Italy	Public (*n* = 55, 80.9%)	47.2 ± 39.6	€901.1 ± 15,04.8	€4375.0 ± 2111.6
Republic of Northern Macedonia	Private (*n* = 1, 100.0%)	NR	NR	€2000.0 ± 0.0
Malta	Public (*n* = 1, 100.0%)	NA	NA	NR
Portugal	Public (*n* = 9, 45.0%)	53.2 ± 44.2	€432.3 ± 79.5	€491.3 ± 379.5

Serbia	Public (*n* = 2, 100.0%)	NA	NA	€587.7 ± 174.9
Slovenia	Public (*n* = 1, 50.0%)	75.0 ± 0.0	€230.0 ± 0.0	€7655.0 ± 756.6
Spain	Public (*n* = 41, 87.2%)	NR	€1650.0 ± 494.9	€1121.7 ± 979.7
Regional average	Public (*n* = 113, 75.8%)	51.0 ± 38.5	€809.2 ± 1087.9	€2163.4 ± 1769.5
Median (Q25–Q75)	NA	35.0 (16.7–100.0)	€200.0 (95.0–1900.0)	€1900.0 (491.0–3512.5)
Western Europe				
Austria	Public (*n* = 4, 80.0%)	NR	NR	€5376.4 ± 4954.1
Belgium	Hybrid (*n* = 7, 77.8%)	9.7 ± 6.8	€225.0 ± 187.6	€1620.0 ± 784.4
France	Public (*n* = 14, 87.5%)	NR	NR	€5330.8 ± 5839.9
Germany	Hybrid (*n* = 29, 85.3%)	12.8 ± 25.9	€304.6 ± 554.5	€1925.2 ± 774.9
Netherlands	Public (*n* = 14, 48.3%)	15.0 ± 0.0	NR	€1333.3 ± 1040.8
Switzerland	Public (*n* = 2, 50.0%)	NR	NR	€1806.7 ± 1341.1
Regional average	Hybrid (n = 43, 44.3%)	12.0 ± 20.9	€279.7 ± 464.6	€3089.6 ± 3724.3

Median (Q25–Q75)	NA	8.0 (0.5–10.0)	€151.0 (2.5–200.0)	€2400.0 (1400.0–3500.0)
Total	Public (*n* = 336, 75.0%)	35.9 ± 36.0	€494.8 ± 830.3	€1846.6 ± 2471.1
Median (Q25–Q75)	NA	18.5 (8.5–71.3)	€150.0 (52.1–324.3)	€1028.2 (528.3–2500.0)
European HICs[e]	Public (*n* = 327, 75.2%)	36.4 ± 36.4	€101.9 ± 273.4	€1845.3 ± 2499.1
Median (Q25–Q75)	NA	17.0 (8.0–75.0)	€18.5 (7.63–99.3)	€1016.7 (525.0–2500.0)
Other HICs	Public (n = 126, 54.3%)	29.6 ± 34.5	€577.0 ± 1,493.8	€1919.3 ± 7663.5
Median (Q25–Q75)	NA	20.0 (7.5–27.5)	€177.8 (44.1–390.8)	€535.7 (169.7–1026.8)

Due to missing data, percentages are computed where the denominator is the number of valid responses from responding programmes.

CR: cardiac rehabilitation; HICs: high-income countries.

[a]Values reported using purchasing power parity (2016 USD) shown in Moghei et al. (under revision, *International Journal of Cardiology*).

b Respondents instructed to select all that apply of: social security/government, hospital/clinical centre, patient, private healthcare insurance, and/or other. To categorise funding source, respondents that selected the 'patient' and/or 'private health insurance' options only were categorised as 'privately funded' programmes; those that selected the 'social security/government' and/or 'hospital/clinical centre' options only were classified as 'public'; those that selected one or more of both the above private and public response options were categorised as 'hybrid'. Then, the most frequent category for a given country was computed.

c This was only in the programmes where patients paid (proportion of programmes not shown. For more

information see: Moghei et al. (under revision, *International Journal of Cardiology*).

d This item assessed total programme costs (i.e. not itemised) and hence was likely to be estimated grossly by respondents. Therefore, there is likely to be considerable measurement error which should be taken into consideration when interpreting the values.

NR: response about CR cost was not provided by any respondent in the country.

NA: not applicable as patients do not pay for any part of CR in this country.

Note: *n* and % or mean ± standard deviation reported in all countries with CR.

e All European countries except: Belarus, Bosnia and Herzegovina, Bulgaria Romania, Russia, Moldova, Republic of Northern Macedonia and Serbia.

Table 3.

Most commonly accepted cardiac rehabilitation indications, by European region and versus other high-income countries.

	Europe				
Region	**Northern (*N* = 150)**	**Eastern (*N* = 56)**	**Southern (*N* = 152)**	**Western (*N* = 97)**	**Total (*N* = 455)**[b]
Myocardial infarction	108 (99.1%)	30 (100.0%)	113 (96.6%)	61 (98.4%)	320 (98.2
Percutaneous coronary intervention	106 (97.2%)	29 (96.7%)	108 (92.3%)	61 (100.0%)	311 (95.7
Bypass surgery	106 (97.2%)	29 (96.7%)	106 (90.6%)	60 (98.4%)	308 (94.8
procedure	104 (95.4%)	28 (93.3%)	90 (76.9%)	60 (98.4%)	288 (88.6
Heart failure	93 (85.3%)	29 (96.7%)	91 (77.8%)	59 (96.7%)	276 (84.9
Chronic stable CAD	65 (59.6%)	23 (76.7%)	89 (76.1%)	56 (91.8%)	237 (72.9

Due to missing data, percentages are computed where the denominator is the number of valid responses from responding programmes.

CAD: coronary artery disease (i.e. with no recent event or procedure).

a Generalised linear mixed models were used to test for significant differences in European HICs and other HICs.

b Generalised linear mixed models were used to test for significant differences by region. None were significant.

Table 4.

Healthcare professionals on the cardiac rehabilitation team, by European region and versus other high-income countries.

	Europe							
Region	**Northern (*N* = 150)**	**Eastern (*N* = 56)**	**Southern (*N* = 152)**	**Western (*N* = 97)**	**Total (*N* = 455)**	**European HICs (*N* = 442)**	**Other HICs (*N* = 234)**	***P* value**[a]
Nurse	118 (93.7%)	43 (100.0%)	125 (95.4%)	62 (91.2%)	348 (94.6%)	338 (94.4%)	188 (91.7%)	0.35
Physiotherapist	103 (83.1%)	40 (93.0%)	125 (94.7%)	63 (91.3%)	331 (89.9%)	323 (90.2%)	118 (58.7%)	<0.001
Cardiologist	60 (48.4%) ¶¶¶	43 (100.0%)	130 (99.2%)	69 (100.0%)	302 (82.3%) †††	292 (81.8%)	105 (52.0%)	<0.05
Dietitian	89 (71.2%)	40 (93.0%)	94 (72.9%)	68 (100.0%)	291 (79.7%)	284 (80.0%)	184 (90.2%)	0.61
Administrative assistant	87 (70.2%) ‡‡	34 (79.1%) ‖‖	87 (69.0%)	64 (94.1%) ‡‡ ‖‖	272 (75.3%) †	265 (75.5%)	116 (58.3%)	0.11
Psychologist	57 (45.6%)¶	38 (88.4%)	111 (84.7%)	67 (98.5%)	273 (74.4%) †††	267 (74.8%)	67 (34.7%)	<0.05
Exercise specialists	69 (55.2%)	24 (55.8%)	46 (36.5%)	54 (79.4%)	193 (53.3%)	186 (52.8%)	120 (60.0%)	0.54
Physiatrist	18 (14.5%)	35 (81.4%)	97 (77.0%)	35 (53.8%)	185 (51.7%)	179 (51.4%)	13 (6.6%)	<0.05

Social worker	31 (24.8%)	23 (53.5%)	48 (39.3%)	60 (88.2%)	162 (45.3%)	159 (45.7%)	107 (53.0%)	0.93
Psychiatrist	12 (9.8%) ╪ ‖‖‖	18 (41.9%) ╪	47 (38.5%) ‖‖‖	15 (23.4%)	92 (26.1%) †††	88 (25.7%)	9 (4.6%)	0.001
Sport medicine physician	3 (2.4%) ╪	8 (18.6%)	20 (16.8%)	32 (50.0%) ╪	63 (18.1%) †	63 (18.5%)	5 (2.5%)	<0.05
Other physician types	19 (15.2%) ╪ ‖	23 (60.5%) ╪	62 (50.8%)	44 (66.7%) ‖	148 (42.2%) †	144 (42.1%)	58 (29.3%)	0.25
Total staff (mean ± SD)	5.2 ± 2.4 ╪	8.2 ± 2.8	6.1 ± 2.4	9.2 ± 3.2 ╪	6.6 ± 3.0 ††	6.6 ± 2.8	5.0 ± 2.1	<0.001

a Generalised LINEAR MIXED MODels were used to test for significant differences in European HICs and other HICs.

† $P<0.05$; †† $P < 0.01$; ††† $P < 0.001$ for generalised linear mixed models testing for significant differences by region.

For pairwise comparisons †‖: one symbol = $P < 0.05$; two symbols = $P < 0.01$; three symbols = $P < 0.001$;

¶Significantly different from all funding sources: one symbol = $P < 0.05$; two symbols = $P < 0.01$; three symbols = $P < 0.001$.

Note: *n* and % reported, with full-time staff counted as 1 and part-time staff counted as 0.5.

Due to missing data, percentages are computed where the denominator is the number of valid responses from responding programmes.

Table 5.
Cardiac rehabilitation elements delivered in European countries (by region) versus other high-income countries.

	Europe			
Region	**Northern (*N* = 150)**	**Eastern (*N* = 56)**	**Southern (*N* = 152)**	**Western (*N* = 97)**
Core components				
Initial assessment	123 (97.6%)	44 (97.8%)	134 (100.0%)	73 (100.0%)
Management of cardiovascular risk factors	123 (97.6%)	44 (97.8%)	133 (99.3%)	72 (98.6%)
Structured exercise/counselling	124 (97.6%)	42 (93.3%)	132 (98.5%)	72 (97.3%)
Patient education	116 (95.1%)	41 (95.3%)	128 (97.7%)	70 (100.0%)
Nutrition counselling	113 (90.4%)	44 (97.8%)	128 (95.5%)	72 (98.6%)
Risk stratification	100 (96.2%)	35 (97.2%)	114 (95.0%)	51 (86.4%)
Prescription and/or titration of medications	88 (70.4%)	43 (95.6%)	133 (99.3%)	69 (94.5%)
Stress management	111 (88.1%)	40 (88.9%)	110 (82.1%)	70 (97.2%)
Communication of assessment results to patients' primary care provider	105 (86.1%)	34 (75.6%)	117 (87.3%)	63 (91.3%)
Tobacco cessation interventions	92 (73.0%)	38 (84.4%)	111 (82.8%)	68 (93.2%)
Mean number core components	8.2 ± 1.8	8.4 ± 1.5	8.8 ± 1.3	8.7 ± 1.4

core components offered ± standard deviation (/10)		1.5		
Other elements				
Heart rate measurement training/exercise intensity monitoring	111 (89.5%)	43 (97.7%)	132 (99.2%)	73 (98.6%)
Assessment of comorbidities	118 (95.2%)	41 (93.2%)	132 (99.2%)	67 (91.8%)
Depression screening	115 (91.3%)	37 (82.2%)	127 (95.5%)	71 (97.3%)
End of programme re-assessment	113 (90.4%)	38 (84.4%)	127 (95.5%)	69 (95.8%)
Resistance training	112 (88.9%)	41 (93.2%)	121 (91.0%)	70 (94.6%)
Psychological counselling	97 (77.0%) ‡‡ ‖‖	40 (88.9%)	124 (92.5%) ‡‡	71 (98.6%) ‖‖
Other functional capacity test	104 (84.6%)	32 (71.1%)	113 (87.6%)	66 (91.7%)
Exercise stress test	46 (37.4%) ¶¶¶	41 (93.2%)	131 (98.5%)	72 (97.3%)
Return-to-work counselling	92 (73.6%)	31 (72.1%)	96 (72.2%)	67 (91.8%) ¶¶
Follow-up post-programme	67 (54.5%) ‡‡	30 (68.2%)	105 (78.4%) ‡‡ ‖	39 (54.2%) ‖
Electronic patient charting	24 (36.4%) ‡‡‡ ‖	26 (57.8%) ‡‡	57 (93.4%) ‡‡‡ ⬨ ‡‡	44 (63.8%) ‖ ⬨

Assessment of strength	35 (27.8%) ╪╪ ⫴	23 (54.8%)	68 (51.5%) ╪╪	44 (62.0%) ⫴
Alternative forms of exercise (yoga, dance)	40 (32.0%)	17 (37.8%)	41 (31.1%)	34 (48.6%)
Other	10 (22.7%)	1 (4.2%)	13 (24.1%)	6 (17.1%)

Generalised linear mixed models were used to test for significant differences by geoscheme region and in European HICs versus other HICs.

† $P < 0.05$; †† $P < 0.01$; ††† $P < 0.001$.

For pairwise comparisons by region ╪⫴‡⋄: one symbol = $P < 0.05$; two symbols = $P < 0.01$; three symbols = $P < 0.001$.

¶Significantly different from all other regions: one symbol = $P < 0.05$; two symbols = $P < 0.01$; three symbols = $P < 0.001$.

HIC: high-income country.

Note: *n* and % or mean ± standard deviation reported.

Due to missing data, percentages are computed where the denominator is the number of valid responses from responding programmes.

a All European countries except: Belarus, Bosnia and Herzegovina, Bulgaria Romania, Russia, Moldova, Republic of Northern Macedonia and Serbia.

Supplemental Table 1- Cardiac Rehabilitation Availability, Volume, Capacity, Density (including Rank) by European Country, Geoscheme Region, and versus other High-Income Countries*

Region	IHD incidence†	Year 1st CR program opened	Median annual volume/ program	Median annual capacity / program	National CR capacity‡	CR density§	CR density ranking‖
Northern Europe							
Denmark	23,455	1990	200	250	8,750	3	10
England	318,284	1978	490	500	133,000	2	8
Estonia	10,938	1994	150	150	300	37	31
Finland	25,677	1978	55	98	2,450	11	21
Iceland	1,570	1983	168	185	740	2	4
Ireland	16,000	1985	256	300	11,100	1	3
Latvia	14,743	1997	150	400	800	18	27
Lithuania	23,421	1977	950	1,000	25,000	1	2
Northern Ireland	8,811	1980	255	215	2,795	3	11
Norway	15,197	-	-	-	-	-	-
Scotland	30,185	1985	1,025	850	58,650	1	1
Sweden	50,475	NA	150	150	10,350	5	17
Wales	15,432	1986	490	375	6,375	2	9
Mean ± SD	42,630±83,685	1985±7	362±321	373±285	21,693± 38,694	7±11	12±10
Median (Q25-Q75)	16,000 (12,841-27931)	1985 (1978-1990)	228 (150-490	275 (159-475)	7,563 (1,213-21,525)	3 (1-10)	10 (3-20)
Eastern Europe							

Belarus	88,874	1981	300	300	1,500	59	34
Bulgaria	55,871	1958	2,200	3,000	3,000	19	28
Czech Republic	66,012	1993	65	200	3,000	22	30
Hungary	69,698	1970	440	580	19,140	4	12
Poland	237,460	1973	350	375	21,000	11	22
Moldova	21,376	2016	200	400	400	53	33
Romania	126,835	1978	1,400	2,500	7,500	17	26
Russia	1,223,642	2010	400	500	1,500	816	36
Slovak Republic	29,436	2015	50	200	1,400	21	29
Mean ± SD	213,245 ± 384,394	1988 ± 21	601 ± 722	895 ± 1,066	6,493 ± 7,974	114 ± 264	28±7
Median (Q25-Q75)	69,698 (42,654-182,148)	1981 (1972-2013)	350 (133-920)	400 (250-1,540)	3,000 (1,450-13,320)	21 (14-56)	29 (24-34)
Southern Europe							
Bosnia and Herzegovina	19,068	1959	800	2,000	2,000	10	20
Croatia	26,066	1957	940	940	2,820	9	19
Greece	61,036	1993	20	100	400	153	35
Italy	359,226	1974	350	355	78,455	5	15
Republic of Northern Macedonia	8,285	-	-	-	-	-	-
Malta	1,958	2012	300	900	900	2	5
Montenegro	3,049	-	-	-	-	-	-
Portugal	35,884	1988	75	100	2,300	16	24
Serbia	40,265	1968	1,345	1,570	3,140	13	23

Slovenia	11,135	1995	100	150	300	37	32
Spain	175,537	1993	120	120	10,440	17	25
Mean ± SD	67,410 ± 108,515	1982 ± 19	450 ± 468	693 ± 709	11,195 ± 25,408	29 ± 48	22 ± 9
Median (Q25-Q75)	26,066 (8,285-61,036)	1988 (1964-1994)	300 (88-870)	355 (110-1,255)	2,300 (650-6,790)	13 (7-27)	23 (17-29)
Western Europe							
Austria	32,901	1962	750	200	5,200	6	18
Belgium	66,985	1977	275	300	14,400	5	16
France	259,251	1984	475	485	63,050	4	14
Germany	385,474	1950	800	825	99,000	4	13
Luxembourg	1,683	-	-	-	-	-	-
Netherlands	88,550	1974	555	450	40,500	2	6
Switzerland	29,546	1997	255	255	13,005	2	7
Mean ± SD	123,484 ± 143,381	1974 ± 16	518 ± 230	419 ± 228	39,193 ± 36,342	4 ± 2	12±5
Median (Q25-Q75)	66,985 (29,546-259,251)	1976 (1959-1987)	515 (270-763)	375 (241-570)	27,450 (11,054-72,038)	4 (2-5)	14 (7-17)
Europe Mean ± SD	101,982 ± 207,600	1983 ± 17	470 ± 224	591 ± 224	18,185 ± 36,115	39 ± 1	-
Europe Median (Q25-Q75)	29,866 (15,256-83,837)	1983 (1974-1993)	300 (150-701)	365 (200-764)	4,170 (1,500-17,955)	7 (2-19)	-
Other HICs*	381,571	1967	213	214	166,884	2	--

†Incidence of IHD was obtained from Global Burden of Disease study(45)

‡National CR capacity calculated using median number of patients a program could serve per year (from survey) multiplied by the number of programs in the country (ascertained from national champions). Value represents the number of patients who could receive CR in a year (i.e., CR spots).
§CR density refers to the number of incident IHD cases per year per CR spot (i.e, national CR capacity).
||Ranking based on density, or ratio of need (i.e., IHD incidence) to supply (i.e., national CR capacity). Lower numbers reflect more CR spots per IHD patient (i.e., of 37 European countries where CR and sufficient information are available such that 1 represents the most spots per IHD patient and 36 is the least spots per patient).
*United States, Canada, Australia and New Zealand. Mean values reported per country (except year first program). Country-level values shown in Turk-Adawi et al.[44] (under review)
CR= Cardiac Rehabilitation
HIC=High-Income Country
IHD= Ischaemic Heart Disease
-not applicable