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

Ana Abreu, MD[1]; Ella Pesah, M.Sc.[2]; Marta Supervia, MD[3]; Karam Turk-Adawi, PhD[4]; Birna Bjarnason-Wehrens, PhD[5]; Francisco Lopez-Jimenez, MD[6]; Marco Ambrosetti, MD[7]; Karl Andersen, PhD[8]; Vojislav Giga, MD[9]; Dusko Vulic, MD[10]; Eleonora Vataman, MD[11]; Dan Gaita, MD[12]; Jacqueline Cliff, RN[13]; Evangelia Kouidi, MD[14]; Ilker Yagci, MD[15]; RN; Attila Simon, MD[16]; Arto Hautala, PhD[17]; Egle Tamuleviciute-Prasciene, MD[18]; Hareld Kemps, MD[19]; Zbigniew Eysymontt, MD[20]; Stefan Farsky, MD[21]; Jo Hayward, RN[22]; Eva Prescott, MD[23]; Susan Dawkes, PhD[24]; Bruno Pavy, MD[25]; Anna Kiessling, PhD[26]; Eliska Sovova, MD[27]; Sherry L. Grace, PhD[28,29] on behalf of the Global CR Program Survey Investigators.

*institutions where the work was performed
[1]Hospital Santa Maria, CHLN, Av. Prof. Egas Moniz, 1649-035 Lisboa, Portugal
[2]Graduate student, York University, 4700 Keele Street, Toronto Ontario, Canada, M3J1P3*
[3]Gregorio Marañón General University Hospital, Gregorio Marañón Health Research Institute, Dr. Esquerdo, 46, 28007 Madrid, Spain
[4]Professor, Qatar University, Al Jamiaa St, Doha, Qatar
[5]Professor, Institute for Cardiology and Sports Medicine, Dep. Preventive and Rehabilitative Sport Medicine and Exercise Physiology, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany
[6]Mayo Clinic, Rochester, 200 First St. SW Rochester, MN 55905, USA*
[7] Istituti Clinici Scientifici Maugeri, Care and Research Institute Department of Cardiac Rehabilitation Via S. Maugeri, 4 – 27100 Pavia, Italy
[8]University of Iceland, Saemundargata 2, IS-101, Reykjavik, Iceland
[9]Institute of Cardiovascular Diseases, Clinical Center of Serbia, Dr. Koste Todorovića 8 11000 Beograd, Serbia
[10]University of Banja Luka, Center for Medical Research, 6 Vuka Karadzica St, 78000 Banja Luka, Bosnia and Herzegovina.

[11]Institute of Cardiology, Moldova Academy of Science, Str. Testemitanu, 20, Chisinau, Republica Moldova
[12]University of Medicine & Pharmacy "Victor Babes" Cardiovascular Prevention & Rehabilitation Clinic Bvd CD Loga 49, 300020 Timisoara, Romania
[13]Betsi Cadwaladr University Health Board, Wrexham Maelor Hospital, Croesnewydd Road, Wrexham, Wales, LL13 7TD
[14]Aristotle University of Thessaloniki, Thessaloniki 57001, Greece
[15]Marmara University School of Medicine, Başıbüyük Mah. Maltepe Başıbüyük Yolu Sk. Sağlık Bilimleri Fakültesi No:9/4/1 Maltepe/İSTANBUL, 34854 Maltepe/Istanbul, Turkey
[16]State Hospital for Cardiology, Balatonfüred, Gyógy tér 2, 8230 Hungary
[17]Cardiovascular Research Group, Division of Cardiology, Oulu University Hospital, University of Oulu, Finland
[18]Lithuanian University of Health Sciences, A. Mickevičiaus g. 9, Kaunas 44307, Lithuania
[19]Maxima Medical Centre, De Run 4600, 5504 DB Veldhoven, Netherlands
[20]Ślaskie Centrum Rehabilitacji w Ustroniu, Zdrojowa 6, 43-450 Ustroń, Poland
[21]Heart House Martin, Bagarova 30, Martin (Podháj), Slovakia
[22]Norfolk and Norwich University Hospital, Colney Lane, Norwich, NR4 7UY, United Kingdom
[23]Bispebjerg Frederiksberg Hospital, Bispebjerg Bakke 23, 2400 København, NV, Copenhagen, Denmark
[24]Edinburgh Napier University, 9 Sighthill Ct, Edinburgh EH11 4BN, Scotland, United Kingdom
[25]Loire-Vendée-Océan hospital, Boulevard des Régents, 44270 Machecoul, France
[26] Karolinska Institutet, Dep. of Clinical Sciences Danderyd Hospital, Stockholm, Sweden
[27]University of Palacky, University Hospital Olomouc, I.P. Pavlova 185/6, Nová Ulice, 779 00 Olomouc, Czech Republic
[28]Senior Scientist, University Health Network, 399 Bathurst St, Toronto, ON M5T 2S8, Canada
[29]Professor, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J1P3*

Corresponding author:

Sherry L. Grace, PhD, FCCS,

York University - Bethune 368, 4700 Keele Street, Toronto, ON Canada M3J 1P3

(416) 736-2100 x.22364

sgrace@yorku.ca

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).

<u>Volumes, Capacity and Density</u>

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 mechanical 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.

Funding

This work was supported by a minor research grant provided by the York University Faculty of Health.

Acknowledgements

On behalf of the International Council of Cardiovascular Prevention and Rehabilitation through which this study was undertaken, we are grateful to others who collaborated with us to identify and reach programs in their European country, namely: Dr. Alexander Aleksiev, Dr. Josef Niebauer, Dr. Borut Jug, Dr. Henrik Schirmer, Dr. Charles Delagardelle, and Mr. Ricky Thomas. We also thank the following associations for assisting with program identification: the British Association of Cardiovascular Prevention and Rehabilitation, European Association of Preventive Cardiology (Secondary Prevention and Rehabilitation Section), the International Society of Physical Medicine and Rehabilitation and World Heart Federation (who also formally endorsed the study protocol).

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.

References

1. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, Ahmed M, Aksut B, Alam T, Alam K, Alla F, Alvis-Guzman N, Amrock S, Ansari H, Ärnlöv J, Asayesh H, Atey TM, Avila-Burgos L, Awasthi A, Banerjee A, Barac A, Bärnighausen T, Barregard L, Bedi N, Belay Ketema E, Bennett D, Berhe G, Bhutta Z, Bitew S, Carapetis J, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. *J Am Coll Cardiol* 2017;**70**:1–25.
2. Wilkins E, Wilson L, Wickramasinghe K, Bhatnagar P, Leal J, Luengo-Fernández R, Burns R, Rayner M, Townsend N. European Cardiovascular Disease Statistics 2017. Brussels; 2017.
3. Shields GE, Wells A, Doherty P, Heagerty A, Buck D, Davies LM. Cost-effectiveness of cardiac rehabilitation: a systematic review. *Heart* 2018;**104**:1403–1410.
4. Anderson L, Oldridge N, Thompson DR, Zwisler A-D, Rees K, Martin N, Taylor RS. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease. *J Am Coll Cardiol* 2016;**67**:1–12.
5. Fihn SD, Gardin JM, Abrams J, Berra K, Blankenship JC, Dallas AP, Douglas PS, Foody JM, Gerber TC, Hinderliter AL, King SB, Kligfield PD, Krumholz HM, Kwong RYK, Lim MJ, Linderbaum J a, Mack MJ, Munger M a, Prager RL, Sabik JF, Shaw LJ, Sikkema JD, Smith CR, Smith SC, Spertus J a, Williams S V. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease. *J Am Coll Cardiol* 2012;**60**:e44–e164.
6. Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, Cooney

MT, Corrà U, Cosyns B, Deaton C, Graham I, Hall MS, Hobbs FDR, Løchen ML, Löllgen H, Marques-Vidal P, Perk J, Prescott E, Redon J, Richter DJ, Sattar N, Smulders Y, Tiberi M, Worp HB Van Der, Dis I Van, Verschuren WMM, Binno S, Backer G De, Roffi M, Aboyans V, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J* 2016;**37**:2315–2381.

7. Gómez-Gonzáleza A, Miranda-Calderínb G, Pleguezuelos-Cobosc E, Bravo-Escobara R, López-Lozanod A, Expósito-Tiradod J, Heredia-Torrese A, Montiel-Trujillof A, Aguilera-Saboridog A, Grupo de Trabajo para las Recomendaciones SORECAR sobre Rehabilitación Cardíaca en la Cardiopatía Isquémica. Recommendations of the Cardio-Respiratory Rehabilitation Society (SORECAR) on cardiac rehabilitation in ischemic heart disease. *Rehabilitacion* 2015;**49**:102–124.

8. Dendale P, Dereppe H, Sutter J De, Laruelle C, Vaes J, Lamotte M, Deroeck A, Mallefroy M, Heyndrickx B, Berger J, Kostucki W, Fortuin A, Hansen D, Brohet C, Vanhees L. Position paper of the Belgian Working Group on Cardiovascular Prevention and Rehabilitation: cardiovascular rehabilitation. *Acta Cardiol* England; 2008;**63**:673–681.

9. British Association for Cardiovascular Prevention and Rehabilitation. Cardiovascular Disease Prevention and Rehabilitation. London; 2017. https://www.bacpr.com/pages/page_box_contents.asp?pageid=791 (7 January 2019)

10. Pavy B, Iliou M-C, Vergès-Patois B, Brion R, Monpère C, Carré F, Aeberhard P, Argouach C, Borgne A, Consoli S, Corone S, Fischbach M, Fourcade L, Lecerf J-M, Mounier-Vehier C, Paillard F, Pierre B, Swynghedauw B, Theodose Y,

Thomas D, Claudot F, Cohen-Solal A, Douard H, Marcadet D. French Society of Cardiology guidelines for cardiac rehabilitation in adults. *Arch Cardiovasc Dis* 2012;**105**:309–328.

11. Bjarnason-Wehrens B, Mayer-Berger W, Meister ER, Baum K, Hambrecht R, Gielen S, German Federation for Cardiovascular P, Rehabilitation. Recommendations for resistance exercise in cardiac rehabilitation. Recommendations of the German Federation for Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2004;**11**:352–361.
12. McCreery C, Cradock K, Fallon N, Duffy R, O Doherty V, Kingston C. Cardiac Rehabilitation Guidelines. Irish Assoc. Card. Rehabil. 2013. http://www.iacr.info/wp-content/uploads/2015/03/IACR-Guidelines2013.pdf (7 January 2019)
13. Achttien RJ, Staal JB, Voort S van der, Kemps HMC, Koers H, Jongert MWA, Hendriks EJM. Exercise-based cardiac rehabilitation in patients with coronary heart disease: a practice guideline. *Neth Heart J* Netherlands; 2013;**21**:429–438.
14. McVeigh G, Bleakney G, Cupples M, Downey B, Doyle S, Hanna D, Herity N, Kilgallen A, McCall J, O'Hare R, Russell C. Guidelines for Cardiac Rehabilitation in Northern Ireland. 2006.
15. BACPR scientific statement: British standards and core components for cardiovascular disease prevention and rehabilitation. 2017;
16. Scottish Intercollegiate Guidelines Network. Cardiac Rehabilitation: A National Clinical Guideline. 2017. https://www.sign.ac.uk/assets/sign150.pdf (7 January 2019)
17. Piepoli MF, Corrà U, Adamopoulos S, Benzer W, Bjarnason-Wehrens B, Cupples M, Dendale P, Doherty P, Gaita D, Höfer S, McGee H, Mendes M,

Niebauer J, Pogosova N, Garcia-Porrero E, Rauch B, Schmid JP, Giannuzzi P. Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery. *Eur J Prev Cardiol* 2014;**21**:664–681.

18. Santiago De Araujo Pio C, Marzolini S, Pakosh M, Grace SL. Effect of Cardiac Rehabilitation Dose on Mortality and Morbidity: A Systematic Review and Meta-regression Analysis. *Mayo Clin Proc* 2017;**92**:1644–1659.
19. Taylor RS, Dalal H, Jolly K, Moxham T, Zawada A. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev* 2014;CD007130.
20. Bjarnason-Wehrens B, McGee H, Zwisler A-DD, Piepoli MF, Benzer W, Schmid J-PP, Dendale P, Pogosova N-GG V, Zdrenghea D, Niebauer J, Mendes M. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. *Eur J Cardiovasc Prev Rehabil* 2010;**17**:410–418.
21. Vanhees L, McGee HM, Dugmore LD, Schepers D, Daele P van. A representative study of cardiac rehabilitation activities in European Union Member States: the Carinex survey. *J Cardiopulm Rehabil* 2002;**22**:264–272.
22. Zwisler A-D, Traeden UI, Videbaek J, Madsend M. Cardiac rehabilitation services in Denmark: still room for expansion. *Scand J Public Health* 2005;**33**:376–383.
23. Tramarin R, Ambrosetti M, Feo S De, Piepoli M, Riccio C, Griffo R, Isyde-208 Investigators of the Italian Association for Cardiovascular Prevention R, Prevention. The Italian Survey on Cardiac Rehabilitation-2008 (ISYDE-2008). Part 3. National availability and organization of cardiac rehabilitation facilities. Official report of the Italian Association for Cardiovascular Prevention,

Rehabilitation and Epidemiology. *Monaldi Arch Chest Dis* 2008;**70**:175–205.

24. Teixeira M, Sampaio F, Brizida L, Mendes M. Reabilitação Cardíaca em Portugal - evolução entre 1998 e 2004. *Rev Port Cardiol* 2007;**27**:815–825.
25. Abreu, A. Bettencourt, N. Fontes P. Panorama Nacional de Reabilitação Cardiaca em 2007-2009. *Rev Port Cardiol* 2010;**29**:545–558.
26. Silveira C, Abreu A. Reabilitação cardíaca em Portugal. Inquérito 2013-2014. *Rev Port Cardiol* 2016;**35**:659–668.
27. E Pleguezuelos, G Miranda, A Gomez LC. Cardiac rehabilitation in Spain. SORECAR survey. Rehabilitacion 2010;44:2-7.
28. Lewin RJ, Ingleton R, Newens AJ, Thompson DR. Adherence to cardiac rehabilitation guidelines: a survey of rehabilitation programmes in the United Kingdom. *BMJ* 1998;**316**:1354–1355.
29. Thompson DR, Bowman GS, Kitson AL, Bono DP de, Hopkins A. Cardiac rehabilitation services in England and Wales: a national survey. *Int J Cardiol* 1997;**59**:299–304.
30. Brodie D, Bethell H, Breen S. Cardiac rehabilitation in England: a detailed national survey. *Eur J Cardiovasc Prev Rehabil* 2006;**13**:122–128.
31. McGee HM, Hevey D, Horgan JH, Irish Association of Cardiac R. Cardiac rehabilitation service provision in Ireland: the Irish Association of Cardiac Rehabilitation survey. *Ir J Med Sci* 2001;**170**:159–162.
32. Bradley JM, Wallace ES, McCoy PM, Dalzell GW. A survey of exercise based cardiac rehabilitation services in Northern Ireland. *Ulster Med J* 1997;**66**:100–106.
33. Campbell NC, Grimshaw JM, Rawles JM, Ritchie LD. Cardiac rehabilitation in Scotland: is current provision satisfactory? *J Public Health Med* 1996;**18**:478–

480.

34. Pesah E, Supervia M, Turk-Adawi K, Grace SL. A review of cardiac rehabilitation delivery around the world. *Prog Cardiovasc Dis* 2017;**60**:267–280.

35. Turk-Adawi K, Sarrafzadegan N, Grace SL. Global availability of cardiac rehabilitation. *Nat Rev Cardiol* 2014;**11**:586–596.

36. Ragupathi L, Stribling J, Yakunina Y, Fuster V, Mclaughlin MA, Vedanthan R. Availability, use, and barriers to cardiac rehabilitation in LMIC. *Glob Heart* 2016;**12**:323–334.

37. United Nations Statistics Division. Standard Country and Area Codes Classifications. 2018. https://unstats.un.org/unsd/methodology/m49/ (7 January 2019)

38. Habib SH, Saha S. Burden of non-communicable disease: Global overview. *Diabetes Metab Syndr Clin Res Rev* 2010;**4**:41–47.

39. Turk-Adawi KI, Terzic C, Bjarnason-Wehrens B, Grace SL. Cardiac rehabilitation in Canada and Arab countries: comparing availability and program characteristics. *BMC Health Serv Res* 2015;**15**:521.

40. Cortes-Bergoderi M, Lopez-Jimenez F, Herdy AH, Zeballos C, Anchique C, Santibañez C, Burdiat G, Gonzalez G, Gonzalez K, Finizola B, Fernandez R, Paniagua M, Thomas RJ, Gonzalez-Moreno J, Rodriguez-Escudero JP, Perez-Terzic C. Availability and characteristics of cardiovascular rehabilitation programs in South America. *J Cardiopulm Rehabil Prev* 2013;**33**:33–41.

41. International Buisness Machines Corporation. Statistical Package for the Social Sciences Software. Armonk, NY: IBM Corp.; 2016.

42. The World Bank. World Bank Country and Lending Groups. 2017. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-

country-and-lending-groups (6 December 2017)

43. Moghei M, Pesah E, Turk-Adawi K, Supervia M, Jimenez FL, Schraa E, Grace SL. Funding sources and costs to deliver cardiac rehabilitation around the globe: Drivers and barriers. *Int J Cardiol* Elsevier; 2019;**276**:278–286.

44. Ghisi GLM, Pesah E, Turk-Adawi K, Supervia Pola M, Lopez Jimenez F, Grace SL. Alternative models of cardiac rehabilitation around the globe. *J Clin Med* 2018;**7**:1–13.

45. Ruivo J, Abreu A, Dendale P, Perk J. Overview of Cardiac Rehabilitation (OCRE) in ESC member countries. Eur. Assoc. Prev. Cardiol. 2018. https://www.escardio.org/static_file/Escardio/Subspecialty/EAPC/Country of the month/Documents/OCRE-2-0-presentation-kit.pdf (7 January 2019)

46. Babu AS, Lopez-Jimenez F, Thomas RJ, Isaranuwatchai W, Herdy AH, Hoch JS, Grace SL, in conjunction with the International Council of Cardiovascular P, Rehabilitation. Advocacy for outpatient cardiac rehabilitation globally. *BMC Health Serv Res* 2016;**16**:471.

47. Huang K, Liu W, He D, Huang B, Xiao D, Peng Y, He Y, Hu H, Chen M, Huang D. Telehealth interventions versus center-based cardiac rehabilitation of coronary artery disease: A systematic review and meta-analysis. *Eur J Prev Cardiol* 2015;**22**:959–971.

48. Rawstorn JC, Gant N, Direito A, Beckmann C, Maddison R. Telehealth exercise-based cardiac rehabilitation: a systematic review and meta-analysis. *Heart* 2016;1–10.

49. Critchley JA, Capewell S. Mortality risk reduction associated with smoking cessation in patients with coronary heart disease: a systematic review. *JAMA* 2003;**290**:86–97.

50. Kotseva K, Wood D, Bacquer D De. Determinants of participation and risk factor control according to attendance in cardiac rehabilitation programmes in coronary patients in Europe: EUROASPIRE IV survey. *Eur J Prev Cardiol* 2018;**25**:1242–1251.

51. Benzer W, Rauch B, Schmid JP, Zwisler AD, Dendale P, Davos CH, Kouidi E, Simon A, Abreu A, Pogosova N, Gaita D, Miletic B, Bönner G, Ouarrak T, McGee H, EuroCaReD study group. Exercise-based cardiac rehabilitation in twelve European countries results of the European cardiac rehabilitation registry. *Int J Cardiol* 2017;**228**:58–67.

52. Poffley A, Thomas E, Grace SL, Neubeck L, Gallagher R, Niebauer J, O'Neil A. A systematic review of cardiac rehabilitation registries. *Eur J Prev Cardiol* 2017;**24**:1596–1609.

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	4 (2-5)	14 (7-17)

					- 72,038)		
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

Table 1. European Countries, Number of Programs per Country, Program Response Rate and Unmet Need

	Number of Programs	Number of Responses	Program Response Rate %	Unmet Need†
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%	4,900
Latvia	2	1	50.0%	13,943
Lithuania	25	9	36.0%	0
Northern Ireland	13	10	76.90%	6,016
Norway	35	0	0.0%	2,072
Scotland‖	69	24	34.8%	9,785§
Sweden	69	1	1.4%	40,125
Wales	17	16	94.1%	9,057
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%	8,285
Malta	1	1	100.0%	1,058

Montenegro	1	0	0.0%	2,674
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‖	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	1538	455	29.6%	3,449,460

countries with CR; 92.5%)				

†annual ischemic 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 patients programs could serve per year [from survey responses in given country] multiplied by the number of programs in the country [ascertained from literature or national champions]; see online supplement and Turk-Adawi et al. under review).

§value estimated as respondents provided capacity by region, not program. 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 9,785.

CR= Cardiac Rehabilitation; NA=not available.

Table 2. Cardiac Rehabilitation Financing and Costs‖

	Most frequent funder (n, %)‡	Proportion of Program Cost Patient Pays (%)|	Direct Cost to Patient (2016 Euros)	Cost to Deliver CR to 1 Patient§ (2016 Euros)
Northern Europe				
Denmark	Public (n=8, 100.0%)	NA	NA	€1,006.7±1,423.7
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	€2,131.8±3,098.1
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	€1,040.0±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±1,025.6*
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	€1,500.0±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	€1,827.8±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 (50.0-72.5)*	€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	€1,264.0±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	€4,375.0±2,111.6

Republic of Northern Macedonia	Private (n=1, 100.0%)	NR	NR	€2,000.0±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	€7,655.0±756.6
Spain	Public (n=41, 87.2%)	NR	€1,650.0±494.9	€1,121.7±979.7
Regional average	Public (n=113, 75.8%)	*51.0±38.5*	*€809.2±1,087.9*	*€2,163.4±1,769.5*
Median (Q25-Q75)	NA	*35.0 (16.7-100.0)*	€200.0 (95.0-1,900.0)	€1,900.0 (491.0-3,512.5)
Western Europe				
Austria	Public (n=4, 80.0%)	NR	NR	€5,376.4±4,954.1
Belgium	Hybrid (n=7, 77.8%)	9.7±6.8	€225.0±187.6	€1,620.0±784.4

France	Public (n=14, 87.5%)	NR	NR	€5,330.8±5,839.9
Germany	Hybrid (n=29, 85.3%)	12.8±25.9	€304.6±554.5	€1,925.2±774.9
Netherlands	Public (n=14, 48.3%)	15.0±0.0	NR	€1,333.3±1,040.8
Switzerland	Public (n=2, 50.0%)	NR	NR	€1,806.7±1,341.1
Regional average	Hybrid (n=43, 44.3%)	12.0±20.9	€279.7±464.6	€3,089.6±3,724.3
Median (Q25-Q75)	NA	*8.0 (0.5-10.0)*	€151.0 (2.5-200.0)	€2,400.0 (1,400.0-3,500.0)
Total	Public (n=336, 75.0%)	35.9±36.0	€494.8±830.3	€1,846.6±2,471.1
Median (Q25-Q75)	NA	18.5 *(8.5-71.3)*	€150.0 (52.1-324.3)	€1,028.2 (528.3-2,500.0)
European HICs*	Public (n=327, 75.2%)	36.4±36.4	€101.9±273.4	€1,845.3±2,499.1
Median (Q25-Q75)	NA	*17.0 (8.0-75.0)*	€18.5 (7.63-99.3)	€1,016.7 (525.0-2,500.0)
Other HICs	Public (n=126, 54.3%)	29.6±34.5	€577.0±1,493.8	€1,919.3±7,663.5

Median (Q25-Q75)	NA	*20.0 (7.5-27.5)*	€177.8 (44.1-390.8)	€535.7 (169.7-1,026.8)

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

CR=Cardiac rehabilitation; HICs=High-Income Countries.

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

|This was only in the programs where patients paid (proportion of programs not shown. For more information see: Moghei, M. et al. (under revision, International Journal of Cardiology).

§this item assessed total program costs (i.e., not itemized) and hence was likely estimated grossly by respondents. Therefore, there is likely 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.

‖values reported using purchasing power parity (2016 USD) shown in Moghei, M. et al. (under revision, International Journal of Cardiology)

*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					**European HICs (N=442)**	**Other HICs (N=234)**	**p***
Region	Northern (N=150)	Eastern (N=56)	Southern (N=152)	Western (N=97)	Total (N=455)○			
Myocardial Infarction	108 (99.1%)	30 (100.0%)	113 (96.6%)	61 (98.4%)	320 (98.2%)	312 (98.1%)	188 (91.7%)	0.87
Percutaneous Coronary Intervention	106 (97.2%)	29 (96.7%)	108 (92.3%)	61 (100.0%)	311 (95.7%)	304 (95.9%)	184 (90.2%)	0.50
Bypass Surgery	106 (97.2%)	29 (96.7%)	106 (90.6%)	60 (98.4%)	308 (94.8%)	301 (95.0%)	118 (58.7%)	0.24
Valve Procedure	104 (95.4%)	28 (93.3%)	90 (76.9%)	60 (98.4%)	288 (88.6%)	282 (89.0%)	105 (52.0%)	<0.05
Heart Failure	93 (85.3%)	29 (96.7%)	91 (77.8%)	59 (96.7%)	276 (84.9%)	272 (85.8%)	116 (58.3%)	0.32

Chronic Stable CAD‖	65 (59.6%)	23 (76.7%)	89 (76.1%)	56 (91.8%)	237 (72.9%)	233 (73.5%)	67 (34.7%)	0.57

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

‖CAD=coronary artery disease (i.e., with no recent event or procedure).

○ Generalized Linear Mixed Models were used to test for significant differences by region. None were significant.

*Generalized Linear Mixed Models were used to test for significant differences in European HICs and other HICs.

Table 4. Healthcare Professionals on the Cardiac Rehabilitation Team, by European Region and versus other High-Income Countries

	Europe					**European HICs (N=442)**	**Other HICs (N=234)**	**p***
Region	Northern (N=150)	Eastern (N=56)	Southern (N=152)	Western (N=97)	Total (N=455)			
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	35	97	35	185	179	13	<0.05

	(14.5%)	(81.4%)	(77.0%)	(53.8%)	(51.7%)	(51.4%)	(6.6%)	
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%) ǂ ‖‖	18 (41.9%) ǂ	47 (38.5%) ‖‖	15 (23.4%)	92 (26.1%) †††	88 (25.7%)	9 (4.6%)	0.001
Sport Medicine Physician	3 (2.4%) ǂ	8 (18.6%)	20 (16.8%)	32 (50.0%) ǂ	63 (18.1%) †	63 (18.5%)	5 (2.5%)	<0.05
Other Physician Types	19 (15.2%) ǂ ‖	23 (60.5%) ǂ	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 ǂ	8.2±2.8	6.1±2.4	9.2±3.2 ǂ	6.6±3.0 ††	6.6±2.8	5.0±2.1	<0.001

*Generalized 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 Generalized Linear Mixed Models testing for significant differences by region;

For pairwise comparisons ǂ: one symbol=p<0·05; two symbols=p<0·01; 3 symbols=p<0·001;

¶Significantly different from all funding sources: one symbol=p<0·05; two symbols=p<0·01; 3 symbols=p<0·001

Note: n and % reported, with full-time staff counted as 1 and part-time staff counted as 0.5. Note: Due to missing data, percentages are computed where the denominator is the number of valid responses from responding programs.

Table 5. Cardiac Rehabilitation Elements delivered in European Countries (by region) vs other High-Income Countries

	Europe					European HICs§ (N=442)	Other HICs (N=234)	p†
Region	Northern (N=150)	Eastern (N=56)	Southern (N=152)	Western (N=97)	Total† (N=455)			
Core Components								
Initial Assessment	123 (97.6%)	44 (97.8%)	134 (100.0%)	73 (100.0%)	374 (98.9%)	363 (98.9%)	206 (98.1%)	0.77
Management of CV Risk Factors	123 (97.6%)	44 (97.8%)	133 (99.3%)	72 (98.6%)	372 (98.4%)	361 (98.4%)	201 (98.0%)	0.91
Structured Exercise / counselling	124 (97.6%)	42 (93.3%)	132 (98.5%)	72 (97.3%)	370 (97.4%)	360 (97.6%)	197 (94.3%)	0.23
Patient Education	116 (95.1%)	41 (95.3%)	128 (97.7%)	70 (100.0%)	355 (97.0%)	346 (97.2%)	203 (98.5%)	0.63

Nutrition Counselling	113 (90.4%)	44 (97.8%)	128 (95.5%)	72 (98.6%)	357 (94.7%)	346 (94.5%)	203 (97.1%)	0.43
Risk Stratification	100 (96.2%)	35 (97.2%)	114 (95.0%)	51 (86.4%)	300 (94.0%)	295 (94.9%)	165 (85.5%)	0.39
Prescription and/or titration of medications	88 (70.4%)	43 (95.6%)	133 (99.3%)	69 (94.5%)	333 (88.3%)	323 (88.3%)	106 (51.0%)	<0.001
Stress management	111 (88.1%)	40 (88.9%)	110 (82.1%)	70 (97.2%)	331 (87.8%)	324 (88.5%)	194 (93.3%)	0.57
Communication of assessment results to patients' primary care provider	105 (86.1%)	34 (75.6%)	117 (87.3%)	63 (91.3%)	319 (86.2%)	311 (86.6%)	198 (95.7%)	0.07
Tobacco Cessation interventions	92 (73.0%)	38 (84.4%)	111 (82.8%)	68 (93.2%)	309 (81.7%)	300 (81.7%)	151 (72.9%)	0.20

Mean number core components offered ± standard deviation (/10)	8.2±1.8	8.4±1.5	8.8±1.3	8.7±1.4	8.5±1.5	8.5±1.5	8.2±1.5	0.39
Other Elements								
Heart Rate measurement training/exercise intensity monitoring	111 (89.5%)	43 (97.7%)	132 (99.2%)	73 (98.6%)	359 (95.7%)	348 (95.6%)	175 (84.5%)	0.30
Assessment of Comorbidities	118 (95.2%)	41 (93.2%)	132 (99.2%)	67 (91.8%)	358 (95.7%)	348 (95.6%)	196 (93.3%)	0.41
Depression screening	115 (91.3%)	37 (82.2%)	127 (95.5%)	71 (97.3%)	350 (92.8%)	343 (93.7%)	195 (93.8%)	0.99
End of program re-assessment	113 (90.4%)	38 (84.4%)	127 (95.5%)	69 (95.8%)	347 (92.5%)	337 (92.3%)	185 (89.8%)	0.44

Resistance Training	112 (88.9%)	41 (93.2%)	121 (91.0%)	70 (94.6%)	344 (91.2%)	335 (91.5%)	190 (91.8%)	0.92
Psychological counselling	97 (77.0%) # ‖	40 (88.9%)	124 (92.5%) #	71 (98.6%) ‖	332 (88.1%) †	324 (88.5%)	167 (79.9%)	0.10
Other functional capacity test	104 (84.6%)	32 (71.1%)	113 (87.6%)	66 (91.7%)	315 (85.4%)	306 (85.5%)	151 (72.6%)	<0.05
Exercise stress test	46 (37.4%) ¶¶¶	41 (93.2%)	131 (98.5%)	72 (97.3%)	290 (77.5%) †††	280 (77.1%)	68 (32.7%)	0.01
Return-to-work counselling	92 (73.6%)	31 (72.1%)	96 (72.2%)	67 (91.8%) ¶¶	286 (76.5%) †	279 (76.9%)	111 (54.1%)	<0.001
Follow-up post-program	67 (54.5%) #	30 (68.2%)	105 (78.4%) #	39 (54.2%) ‖	241 (64.6%) †	232 (64.1%)	132 (63.8%)	0.98

			‖					
Electronic patient charting	24 (36.4%) ## ‖	26 (57.8%) ‡‡	57 (93.4%) ## ◊ ‡‡	44 (63.8%) ‖ ◊	151 (62.7%) †††	144 (62.3%)	104 (50.2%)	0.59
Assessment of strength	35 (27.8%) # ‖‖	23 (54.8%)	68 (51.5%) #	44 (62.0%) ‖‖	170 (45.8%) ††	164 (45.4%)	71 (35.1%)	0.08
Alternative forms of exercise (yoga, dance)	40 (32.0%)	17 (37.8%)	41 (31.1%)	34 (48.6%)	132 (35.5%)	129 (35.7%)	65 (31.6%)	0.64
Other	10 (22.7%)	1 (4.2%)	13 (24.1%)	6 (17.1%)	30 (19.1%)	30 (19.6%)	12 (22.2%)	0.58

Generalized 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 ǂǁ‡◊: one symbol=p<0.05; two symbols=p<0.01; 3 symbols=p<0.001; ¶Significantly different from all other regions: one symbol=p<0.05; two symbols=p<0.01; 3 symbols=p<0.001

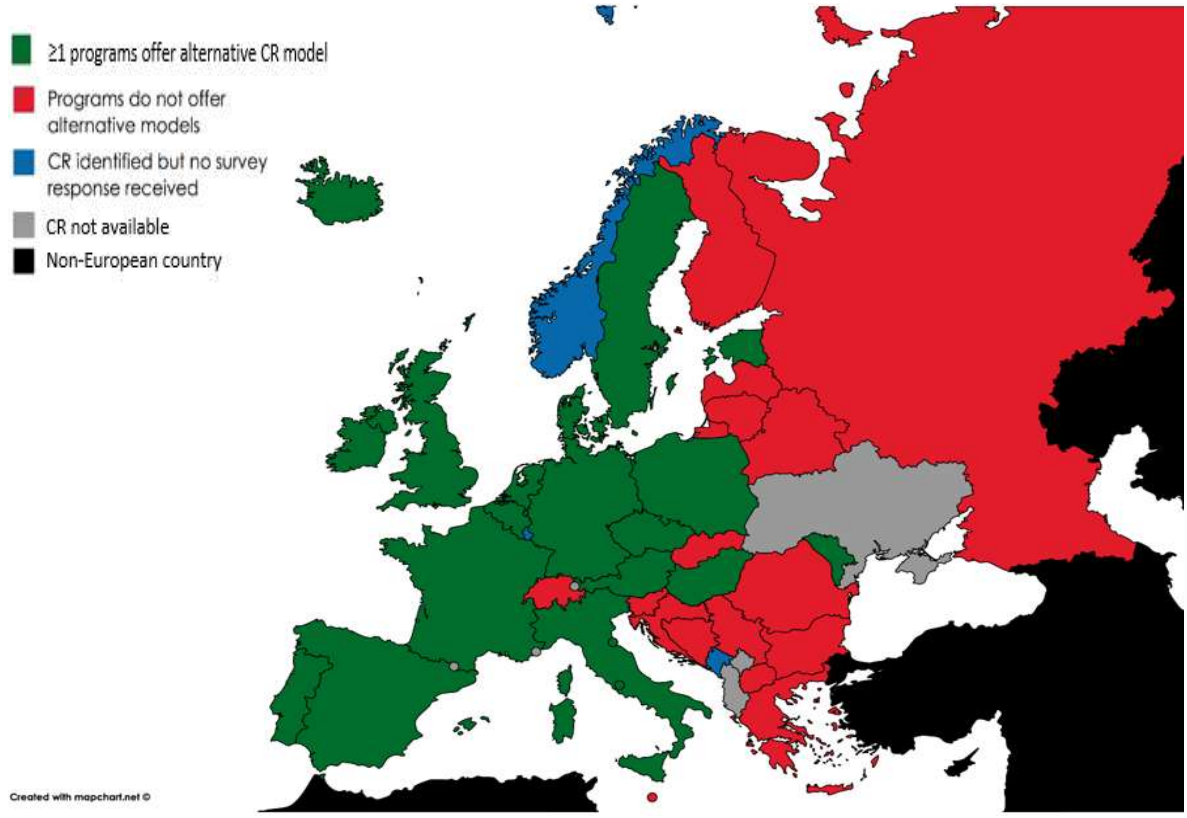
CV= Cardiovascular; HIC= High Income country

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

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

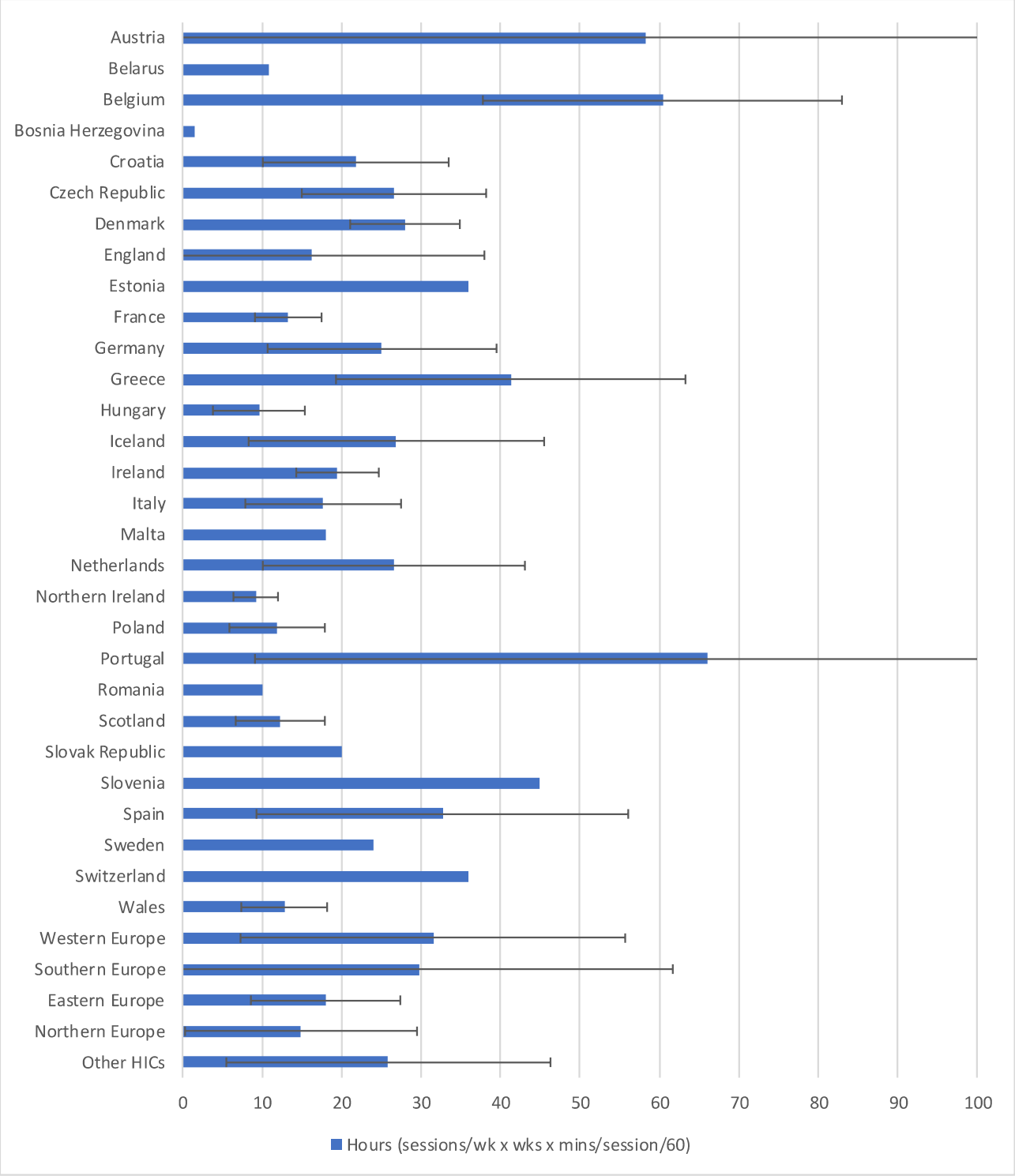
§All European countries except: Belarus, Bosnia and Herzegovina, Bulgaria Romania, Russia, Moldova, Republic of Northern Macedonia and Serbia.

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 / program), by European Country* vs Other High-Income Countries



*insufficient information to compute dose (i.e., frequency, program 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.

Note: whiskers denote standard deviation. Where missing, n=1.

Note: Dose significantly differed by region; $p<.05$.