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Cardiac rehabilitation availability and delivery in Europe: How does it differ by region and compare with other high-income countries?

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Abstract

Aims: The aims of this study were to establish cardiac rehabilitation availability and density, as well as the nature of programmes, and to compare these by European region (geoscheme) and with other high-income countries.

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Methods: A survey was administered to cardiac rehabilitation programmes globally. Cardiac associations were engaged to facilitate programme identification. Density was computed using global burden of disease study ischaemic heart disease incidence estimates. Four high-income countries were selected for comparison ($N = 790$ programmes) to European data, and multilevel analyses were performed.
Results: Cardiac rehabilitation was available in 40/44 (90.9%) European countries. Data were collected in 37 (94.8% country response rate). A total of 455/1538 (29.6% response rate) programme respondents initiated the survey. Programme volumes (median 300) were greatest in western European countries, but overall were higher than in other high-income countries ($P < 0.001$). 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 programmes 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 the programme costs (or ~18.5% of the ~€150.0/programme) out of pocket. Guideline-indicated conditions were accepted in 70% or more of programmes (lower for stable coronary disease), with no regional variation. Programmes had a multidisciplinary team of 6.5 ± 3.0 staff (number and type varied regionally; and European programmes had more staff than other high-income countries), offering $8.5 \pm 1.5/10$ core components (consistent with other high-income countries) over 24.8 ± 26.0 hours (regional differences, $P < 0.05$).
Conclusion: European cardiac rehabilitation capacity must be augmented. Where available, services were consistent with guidelines, but varied regionally.

Keywords
Cardiac rehabilitation, Europe, survey

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Introduction

Similar to other high-income countries (HICs), cardiovascular diseases (CVDs) 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 also associated with 20% reductions in cardiovascular mortality and morbidity,[4,5] clinical practice guidelines[6] for CVD revascularisation 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 multidisciplinary team of healthcare professionals with expertise in all the secondary prevention recommendations.[17] It is recommended that programmes 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 two previous surveys of national coordinators.[20,21] There have also been surveys of individual programmes in Denmark,[22] Italy,[23] Portugal,[24–26] Spain[27] and the United Kingdom,[28–33] but this is only five of the approximately 44 countries in Europe. These surveys did characterise 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 programmes 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 characterise the availability, volumes, capacity and density of CR by European country, region, and in relation to other HICs; and to characterise the following aspects of CR: (a) who pays for services and costs; (b) the type of patients served; (c) the number and types of healthcare professionals on the CR team; (d) the number of programme sessions/dose; (e) the core

components delivered; and (f) the delivery of alternative models, again by European country, region, and in comparison with other HICs.

Methodology

Design and procedure

This research was cross-sectional in design; detailed methods are reported elsewhere (Supervia et al., under review).[35] In brief, countries where CR services were available were identified first through previous reviews.[36,37] 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 programmes or verify lack thereof.

For each country identified to offer CR, the 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 email requesting their collaboration to determine the number of programmes in their country, and assist with administration of the survey to each programme in their country.

Each identified programme 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 programmes identified in the world that offer services to patients following an acute cardiac event or hospitalisation (i.e. phase II). The inclusion criteria were CR programmes that offered: (a) initial assessment; (b) structured exercise; and (c) at least one other strategy to control cardiovascular risk factors.

For the purposes of this study, CR programmes in European countries (according to the geoscheme regions;[38] small islands and jurisdictions were excluded, e.g. Aland islands, Vatican City) as well as in four other HICs (United States, Canada, Australia and New Zealand; i.e. countries most comparable with European HICs) were selected.

Measures

With regard to the first objective, CR availability referred to the existence of one or more programme in a country. Programme volume was defined as the median number of patients served by a programme annually (programme reported in survey, described below). National and regional CR capacity were computed by multiplying the median number of patients a programme could serve annually (programme reported in survey) among the responding programmes in a given country or region, respectively, multiplied by the total number of programmes 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 programmes by median regional programme volumes. Finally, to compute density, ischaemic heart disease (IHD) incidence was pulled from the global burden of disease study.[39] 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.[40] In short, items were based on previous national/regional CR programme surveys.[20,41] 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).[35]

The following variables were assessed: (a) who funds the programme (i.e. private sources such as healthcare insurance, public sources such as government, or a combination of these sources (i.e. hybrid)); (b) the type (e.g. myocardial infarction, as well as non-cardiac indications) and the number of patients served per session (as well as staff-to-patient ratio); (c) the number and types of healthcare professionals on the CR team (part-time staff were counted as 0.5); (d) dose of CR (in hours; i.e. sessions per week $\times$ duration in weeks $\times$ duration of exercise sessions in minutes/60); (e) 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 (f) whether the programme offers alternative CR models (i.e. home or community-based programmes, or hybrid models where patients transition from supervised to unsupervised settings).

Data analysis

SPSS version 24 was used for analysis.[42] 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 characterise 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/categorised. Aspects of CR were then compared nationally, regionally and versus other HICs using generalised linear mixed models to take into consideration the hierarchical nature of data (e.g. CR programmes nested within countries) where applicable and there were sufficient data in each country for estimates to be generated. Otherwise analysis of variance (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, eight (Belarus, Bosnia and Herzegovina, Bulgaria Romania, Russia, Moldova, Republic of Northern Macedonia and Serbia) were not considered high-income as per the World Bank.[43] No response was obtained from Montenegro, Norway and Luxembourg (Figure 1).

In terms of programmes, 455/1538 responded in Europe (29.6%; Table 1). Please note a subsample of programmes only was surveyed in Austria and Scotland (one to two programmes per health board/region for the latter) due to champion preference. Of the four HICs selected for comparison that had CR, 234 surveys were initiated (30.1% response rate).

Volumes, capacity and density

The number of programmes per country and region is shown in Table 1. Of responding programmes, 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%) programmes reported that there was another CR programme within a 20 km radius (vs. 87 (38.7%) in other HICs).

Volumes, capacity and density are shown in Supplementary Table 1. Volumes per programme (median 300) were greatest in Western Europe (median 515). Programme 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 27,450 for western). It was significantly higher than the other HICs.

Overall, European density was one spot per a median of seven IHD patients/year/country (per two for northern countries, 21 for eastern, 13 for southern and per four patients for western region; Supplementary Table 1). In other HICs, the density was on average one spot for two 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

Programme responders were asked to report who pays for their services, and could check all applicable sources ($n = 112$, 25.7% reported more than one source; Table 2). Overall, 312 (69.5%) programmes 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 ($P = 0.15$). The funding source in Europe was not different from other HICs ($P = 0.50$).

In 15 (3.3%) programmes, the sole source of funding was the patient ($P < 0.001$; data shown by country elsewhere).[44] Table 2 also displays the proportion of the total programme 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).[44] 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 (€2163 and €3090). There was also no difference from other HICs for the cost to deliver a full course of CR ($P > 0.05$).

The most common types of patients accepted in CR programmes are shown in Table 3 (shown by country in Supervia et al., under review).[35] 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 programmes 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%).

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

(continued)

Table 1. Continued.

	Number of programmes	Number of responses	Programme response rate (%)	Unmet need[a]
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.

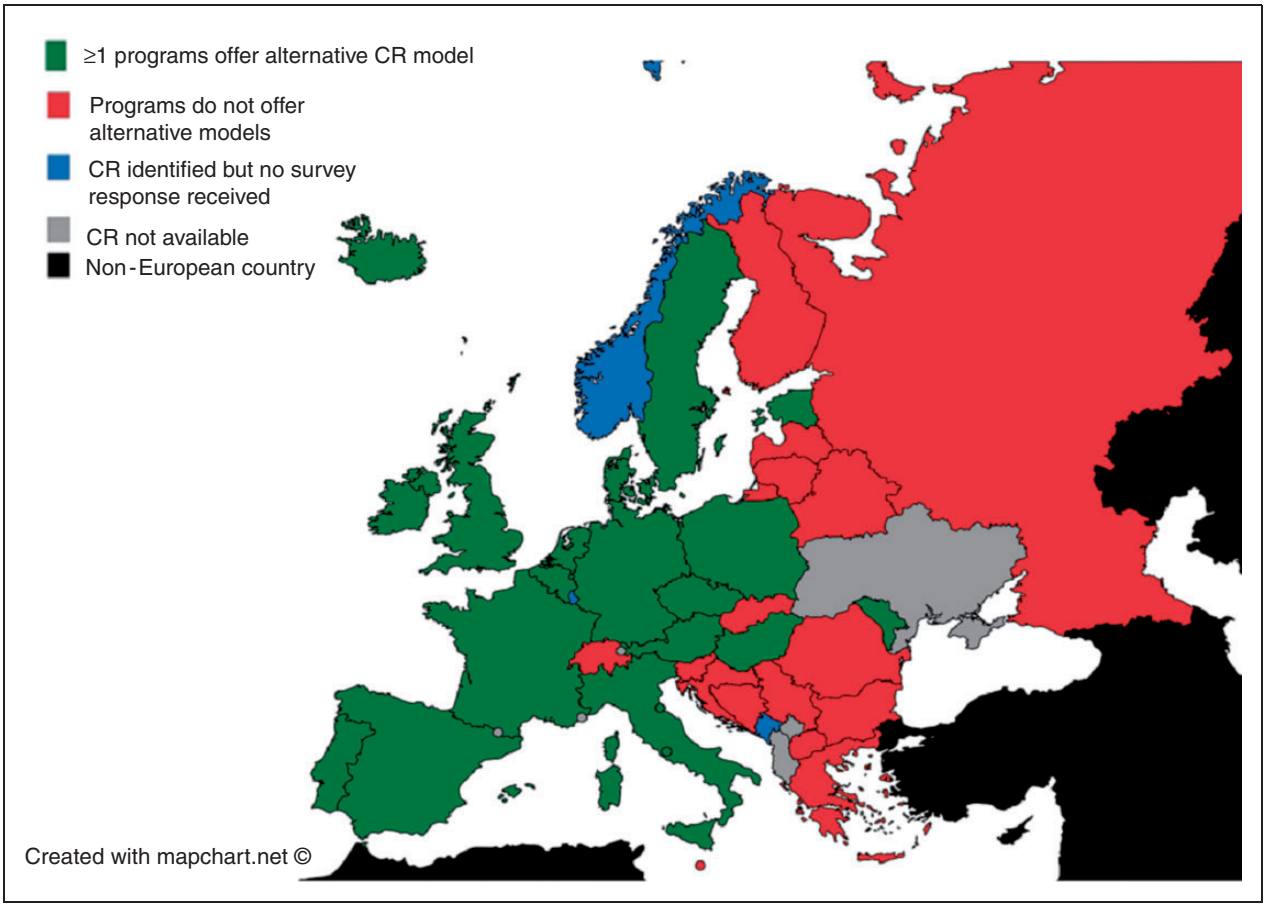

Figure 1. Delivery of alternative cardiac rehabilitation models* by European country. *Home-based (including eCR), community-based or hybrid (i.e. supervised transitioning to unsupervised setting).
CR: cardiac rehabilitation. *'Take-home figure'*.

The number and nature of healthcare professionals on CR teams are shown in Table 4 (shown by country in Supervia et al., under review);[35] programmes on average had 6.5 staff members, most commonly a nurse, physiotherapist, cardiologist, dietitian and administrative assistant. There was significant regional variation in the total number (higher in west than north), and type (i.e. fewer cardiologists (among other

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

(continued)

Table 2. Continued.

	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)
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)

(continued)

Table 2. Continued.

	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)
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.

physicians), psychologists and administrative assistants in north) of providers. When compared with 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 nine (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 programme 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.

Programmes offered 8.5/11 'core' components on average (Table 5; shown by country in Supervia et al., under review),[35] this did not vary significantly by region. There was some significant regional variation in the provision of return-to-work counselling (higher in west), among some other elements. There were some significant differences in the 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-programme, and equipment to deliver components are reported elsewhere by country (Supervia et al., under review).[35]

Finally, alternative CR model delivery is shown in Figure 1; 119 (33.5%) programmes reported delivery of any alternative model (more detail on type is shown in Ghisi et al.).[45] Twenty-five (21.0% of programmes that offered alternative models, or 5.5% of all programmes) programmes reported using smartphones, an 'app' or text messaging with patients (i.e. some form of eCR). There was significant variation by region ($P < 0.05$), but there was not significantly different alternative model implementation when compared with other HICs ($P > 0.05$).

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 programmes each treating 300 patients (with guideline-

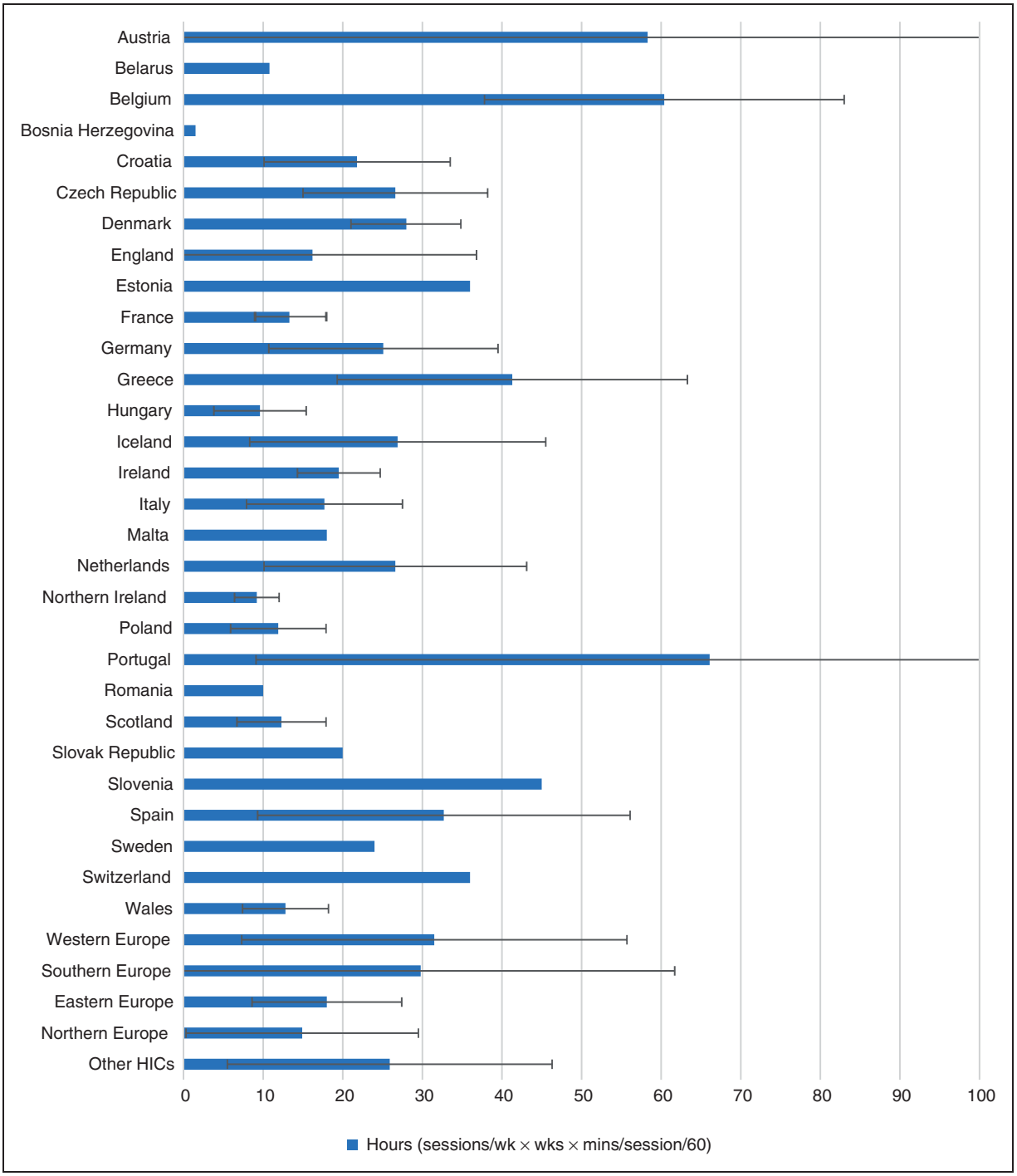

Figure 2. Mean cardiac rehabilitation dose (hours/programme), by European country* versus other high-income countries.
*Insufficient information to compute dose (i.e. frequency, programme duration, or session duration were not reported) for the following countries: Finland, Latvia, Lithuania, Bulgaria, 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: $P < 0.05$.

indicated conditions accepted in ≥85% of programmes, but stable coronary disease less so) per year. Government is the most common CR funding source for programmes that cost a mean of ~€1850, but in approximately 40% of programmes patients are paying out of pocket (for 35% of the programme cost or ~€500/patient/programme). Patients are prescribed a median of 16 hours of CR (which is considered

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]	European HICs ($N=442$)	Other HICs ($N=234$)	*P* value[a]
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
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

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

(continued)

Table 4. Continued.

Region	Europe					European HICs ($N = 442$)	Other HICs ($N = 234$)	P value[a]
	Northern ($N = 150$)	Eastern ($N = 56$)	Southern ($N = 152$)	Western ($N = 97$)	Total ($N = 455$)			
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.

Region	Europe					European HICs[a] ($N = 442$)	Other HICs ($N = 234$)	p†
	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 cardiovascular 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

(continued)

Table 5. Continued.

Region	Europe					European HICs[a]	Other HICs	p†
	Northern (*N* = 150)	Eastern (*N* = 56)	Southern (*N* = 152)	Western (*N* = 97)	Total† (*N* = 455)	(*N* = 442)	(*N* = 234)	
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 programme 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%) ǂǂ ‖‖	40 (88.9%)	124 (92.5%) ǂǂ	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-programme	67 (54.5%) ǂǂ	30 (68.2%)	105 (78.4%) ǂǂ ‖	39 (54.2%) ‖	241 (64.6%) †	232 (64.1%)	132 (63.8%)	0.98
Electronic patient charting	24 (36.4%) ǂǂǂ ‖	26 (57.8%) ‡‡	57 (93.4%) ǂǂǂ ◇ ‡‡	44 (63.8%) ‖ ◇	151 (62.7%) †††	144 (62.3%)	104 (50.2%)	0.59
Assessment of strength	35 (27.8%) ǂǂ ‖‖	23 (54.8%)	68 (51.5%) ǂǂ	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

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 ǂ‖‡◇: 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.

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 programmes in Europe (although the European Society of Preventive Cardiology has recently re-surveyed national coordinators (but not individual programmes),[46] and so we look forward to those results becoming available). Results are fairly consistent with the previous surveys of programmes 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.[47] Recommendations to augment capacity include initiating services in countries without CR, and expanding provision of eCR,[48,49] particularly in Russia, Belarus and Greece where unmet need is greatest. Programme-level innovations recommended on the basis of this work include more consistent provision of return-to-work counselling to optimise life functioning for patients and reduce the negative impacts of CVD on the economy. Moreover, given that tobacco cessation is the most impactful change for secondary prevention,[50] 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,[51] bolstering our call for more focus on this component in European CR programmes.

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 programmes, how these translate to patient outcomes cannot be ascertained. Field tests of CR programmes, 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,[52] and it would be ideal to link this structural programme 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,[53] 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 programmes or differences in the nature of programmes 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 programme rate was 30% in the current study, which is fair, but suggests there may be bias (potentially higher quality programmes 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.[51] Fourth, CR in Europe was compared with only four other HICs; comparisons with 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 over 1500 CR programmes across Europe, existing in ~90% of countries. However, there is only one spot for every seven patients in need (with particularly great need for capacity increases in Eastern Europe), although this density is quite good compared with other regions of the globe. Programme 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 programme volumes, the number and nature of providers on CR teams and the type of core components offered.

Author contribution

MS, KTA, SLG, FLJ, BBW contributed to the conception or design of the work. EP, MS, KTA, AA, MA, KA, VG, DV, EV, DG, JC, EK, IY, AS, AH, ETP, 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 authors gave final approval and agree to be accountable for all aspects of the work ensuring integrity and accuracy.

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