A Review of Cardiac Rehabilitation Delivery Around the World

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ABSTRACT
Herein, 28 publications describing cardiac rehabilitation (CR) delivery in 50 of the 113 countries globally suspected to deliver it are reviewed, to characterize the nature of services. Government funding was the main source of CR reimbursement in most countries (73%), with private and patient funding in about ¼ of cases. Myocardial infarction patients and those having revascularization were commonly served. The main professions delivering CR were physicians, nurses, and physiotherapists. Programs offered a median of 20 sessions, although this varied. Most programs offered the core components of exercise training, patient education and nutrition counselling. Alternative models were not commonly offered. Lack of human and/or financial resources as well as space constraints were reported as the major barriers to delivery. Overall, CR delivery has been characterized in less than half of the countries where it is offered. The nature of services delivered is fairly consistent with major CR guidelines and statements.

Keywords: cardiac rehabilitation, global health, secondary prevention

Alphabetical List of Abbreviations:
AS= administrative support
CABG = coronary artery bypass graft
CB = community-based
CR = cardiac rehabilitation
CPR= cardiopulmonary resuscitation
CVD = cardiovascular disease
ECG = electrocardiogram
EQ= equipment
ET = exercise training
FR= financial resources
HB = home-based
HF = heart failure
HR= human resources
IA = initial assessment
IB = internet-based
IHD = ischemic heart disease
LMIC = low- and middle-income country
MI = myocardial infarction

NC = nutrition counseling
NZ = New Zealand
PAW= patient awareness
PCI = percutaneous coronary intervention
PE = patient education
PR= patient referral
RF = risk factor management
SC = smoking cessation
SM = stress management and/or psychosocial support/counselling
TI = transportation issues
UAE = United Arab Emirates
VAD = ventricular assist device

By 2030, it is expected 84 million individuals will be diagnosed with cardiovascular disease (CVD)[1]. Moreover, it is among the leading causes of disability around the world, and contributes to 10% of disability-adjusted life years lost world-wide[2]. With improved survival (in high-income countries[3]), clearly there is a great need for secondary prevention, such as is offered in cardiac rehabilitation (CR) programs.

Many meta-analyses demonstrate that participation in CR is associated with improved quality of life, as well as decreased morbidity and mortality[4–7]. CR is also cost-effective[8]. Accordingly, it is a class 1 level A recommendation in clinical practice guidelines for CVD patients[9,10].

The International[11,12], British[13] and Canadian[14,15] Associations for Cardiovascular Prevention and Rehabilitation, American Association of Cardiovascular and Pulmonary Rehabilitation[16], Australian Cardiovascular Health and Rehabilitation Association[17], and the European Association of Preventive Cardiology[18], among others[19], have established guidelines to ensure consistent provision and quality of CR delivery in order to achieve the greatest population health benefits. They all outline the nature of patients indicated for services, and make recommendations regarding the composition of a multi-disciplinary CR team. They also establish the core components such as initial assessment, structured exercise training, nutrition counseling, patient education, risk factor management and psychosocial support.

Recently a review of all CR guidelines was undertaken, which compared recommendations across countries[20]. While some consistencies were noted, much variation was identified, raising questions about the nature of CR services delivered around the globe. There have been few reviews of the nature of CR services on a global scale[21,22]. However there have been a considerable number of studies reporting on national or regional surveys of CR

programs[23–26]. To our knowledge these have never been reviewed, with an eye to understanding how CR services conform to practice guidelines in different regions of the world. This is important as results of some of these national surveys have shown that services may not meet minimum standards[27]. Therefore, the objectives of this narrative review were to identify these studies, to summarize and evaluate what is known about the nature of CR services, namely: funding sources, type and number of patients served, staff composition, number of sessions recommended, components delivered, alternative model offerings, and barriers to delivery, by country and region of the world.

METHODS

Studies reporting results of surveys assessing delivery and/or components of comprehensive phase II CR programs on a national or regional level were sought for this narrative review. Sources were identified by searching MEDLINE, PubMed and Scopus. Examples of search terms included: "cardiac rehabilitation", "components", "characteristics", "survey", "status" and "inventory". Articles were also identified by consulting with experts in the field, as well as hand-searching reference lists of CR reviews.

CR characteristics of interest primarily included: capacity and resources, reimbursement sources (i.e., government, social security, private insurance), staff composition (i.e. nurses, cardiologists, physiotherapists), patient diagnoses accepted into CR programs (i.e. myocardial infarction, percutaneous coronary intervention, angina), dose (program duration x session frequency), core components delivered (i.e. physical training, patient education, dietary counseling), alternative model delivery and barriers. All studies reporting results of surveys describing at least one of these characteristics in the English language were included. Studies

with English-language abstracts, where the full publications were not available in English, were described but not included in data synthesis.

Studies were classified by world regions according to the World Bank classification (i.e. East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, North America, South Asia and Sub-Saharan Africa)[28]. Data was extracted in tabular format and summarized qualitatively.

RESULTS

A total of 35 publications were included, describing CR in 50 (25%) of the 203 countries of the world, or (44%) of the 113 countries (manuscript in preparation) where CR is known to be offered. Forty-two were high-income countries[28], with the remaining from middle-income countries. Multiple studies were identified in the United Kingdom, Europe (including Portugal), as well as North and South/Latin America. Figure 1 displays the countries with CR where a study was identified.

An additional 10 citations were identified (total=45). There were 4 English-language abstracts identified describing CR in Chile, Italy, Hong Kong and Mexico[29–33], but the full publications were not available in English. There were also 6 papers identified describing CR but they did not report primary data (Germany, Hong Kong, Singapore, Switzerland and Thailand[34–39]). These publications were summarized in the text only. Two non-English publications were found in Japan and Spain[40,41] that were excluded. Finally, an issue of *Progress in Cardiovascular Diseases* was comprised of narrative reviews on CR delivery in Canada, United States, Brazil, Latin America, India and Japan[42–47]. What primary data could be gleaned from these sources were summarized in the text.

A summary of findings from included studies is shown in Table 1, except those with a specific focus on an aspect of CR delivery (e.g., ventricular assist device patients [VAD]; these are described in text only). No studies were identified in the following regions: Sub-Saharan Africa and South Asia. Thirteen (57%) of the included studies were published since 2010, and hence can be considered fairly current. The response rate across all studies is reported in the Table, with summary statistics for all major elements for each region and overall shown at the bottom. The total number of programs identified by country ranged from a minimum of 1[24] to a maximum of 1000[48], with a median of 65. Results not shown in the table are summarized below.

CR Delivery in East Asia and the Pacific

There have been 6 studies in this region, reporting on CR services in Australia, China, Japan and New Zealand (4 [11%] of 38 countries; 1 [4%] of 23 low and middle-income countries [LMICs]). There were also two descriptive studies found for Germany and Switzerland,[36,39] and therefore these were not included in Table 1 but are described below.

First, a survey conducted in Australia and New Zealand (NZ)[49] aimed to describe the prevalence of cardiopulmonary resuscitation (CPR) training for patients and their families in CR programs (and hence is not shown in Table 1). Surveys were completed by 253 (47%) phase II programs; 206 (46%) in Australia and 45 (52%) in New Zealand. Findings indicated CPR training was only available in 74 (30%) CR programs. The training was delivered by nurses (82%), physiotherapists (8%), and exercise physiologists (4%). Major barriers to CPR training in CR were lack of resources (50%), awareness (34%) and time (11%).

Two national surveys were conducted in Australia. The first aimed to describe the status of CR in Australia[50]. Findings indicated that the mean exercise session duration was 55 minutes. In addition to those shown in Table 1, other healthcare professionals on the teams were

pharmacists (69%), occupational therapists (61%) and social workers (52%). Psychological counselling (86%), and medication education (86%) were also offered in most programs. The second[51] study aimed to describe screening and assessment of psychosocial risk factors in CR programs (and hence was not shown in Table 1). Surveys were completed by 165 (49%) phase II programs. Of these, 157 (95%) screened at entry and 132 (80%) screened at exit. Patient screening was undertaken by nurses (98%), physiotherapists (46%), and exercise physiologists (15%). Major barriers to screening included insufficient staff time (44%), lack of funding (24%), lack of administrative support (24%), and lack of space (21%).

In the survey conducted in New Zealand[52], findings indicated that 50% of programs had a session frequency of 1 session per week. In addition to the core components shown in Table 1, stress management (94%), smoking cessation (79%), and weight management (59%) were also included in most CR programs. The survey also assessed support for special populations (i.e. Maori and Pacific peoples). Results showed that 56% of programs provided a specific cultural provider or liaison, but 29% of programs offered no support for these patients.

In the survey in China[53], findings indicated programs were only available in 8% of hospitals. In addition to providers shown in Table 1, CR teams included clinical educators (31%), exercise physiologists (15%), and psychologists (15%). Dietary counseling and smoking cessation were also offered in all CR programs. In addition to the major diagnoses shown in Table 1, most programs also accepted patients with pacemakers (92%) and post-coronary artery bypass graft surgery (CABG; 69%). Major barriers to establishing CR (specified in this paper in addition to those to delivering CR) were mainly lack of interest (58%), human resources (58%), awareness (50%), and space (47%).

An English-language abstract[33] and study[34] describing CR in Hong Kong specifically were also identified. The abstract outlined a survey that was completed by 9 phase II CR programs. Results showed that all CR teams include cardiologists, nurses and physiotherapists. The descriptive study outlined phase II CR components that included exercise training, relaxation therapy, and risk factor management.

There were 4 publications in Japan, based on surveys of hospitals (including designated cardiology training centres), regarding their delivery of CR. In the survey conducted in 1999[54] 76 hospital directors were contacted and 46 responded (61%). Results indicated that 21% of MI patients participated in CR. In the 2007 survey[55], findings indicated CR programs were only available in 5% of hospitals. Only 6% of facilities were approved for CR. Assuming all patients transferred from phase I CR, phase II programs served an estimated 4,896 patients. Barriers to implementing CR other than those reported in Table 1 included lack of space (23%), and 12% of hospitals believed CR was not necessary. A second publication[56] based on the 2007 survey[55] analyzed patient safety in CR. Findings indicated the rate of adverse events was 12 events/ 383, 096 patient hours. The final publication[57] was based on a 2009 national survey[40] and aimed to examine the CR referral process in Japan. Findings indicated that outpatient CR was implemented in 18% of hospitals, which was an increase from the previous assessment.

In addition, there was a narrative review[44] comparing CR status between the 2004 survey (described above) and the 2009 survey (published in Japanese)[40]. This reported that public health insurance covers only 70% of CR costs for patients under 70 years old and 90% for patients over 70 years old. In terms of CR implementation, rates doubled from 9% to 21%, however CR was still only offered in 325 (4%) of 8,245 hospitals. On average, patients have a longer hospital stay which can explain the in-patient nature of CR in Japan. A major barrier cited was patient referral;

there is no system of referral in Japan, and if the patient has not been treated in a facility that offers CR they will not participate in any CR at all. Finally, another national survey was conducted in 2015 (personal communication, Yoichi Goto, October 24, 2016); the results of this survey are greatly awaited.

In the paper describing CR in Singapore[35] , 3 phase II CR programs were identified. All programs included exercise training and patient education. Phase II programs from 2 centers were described in detail. Program durations were 6 and 12 weeks respectively, with a session frequency of 3 sessions/week. Both centers included nurses and physiotherapists as part of the CR team. The main center accepted patients with myocardial infarction(MI), CABG, percutaneous coronary intervention (PCI), heart transplant, angina, heart failure and valvular disease.

In the paper describing the status of CR in Thailand[38], 5 CR programs were identified (phase was not specified). These programs included exercise and lifestyle modification. The barriers to patient participation in CR listed were time constraints, transportation, and lack of a caregiver to take them to sessions.

CR Delivery in Europe and Central Asia

There have been 15 studies in this region, covering CR in the following 32 countries: Austria, Belarus, Belgium, Croatia, Cyprus, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Norway, Northern Ireland, Poland, Portugal, Romania, Russia, Serbia, Slovak Republic, Scotland, Spain, Sweden, Switzerland, and Wales (54% of 59 European / Central Asian countries; 4 [19%] of 21 regional LMICs). One English language abstract in Italy[31] and 1

descriptive study in Switzerland[36] were also identified. Of note, 3 (23.1%) of these studies noted phase II CR services being provided in a residential setting.

Three regional surveys were conducted in Europe. In the first survey[58], findings indicated that most programs offered 20-29 exercise sessions (40%). In addition to those shown in Table 1 other healthcare professionals on the teams were dietitians, psychologists and social workers. Another core component that was also offered in many phase II programs was smoking cessation.

The second of these studies[23] was completed by respondents each describing CR delivery in their entire country. Twenty-four (86%) of these countries were high-income. Results showed that majority of CR programs had a duration ranging between 6-12 weeks. As well as the major diagnoses presented in Table 1, CR programs also accepted patients with heart transplants (46%). Finally, many countries offered residential phase II programs; 3 (11%) countries offered only such programs, and 18 (64%) offered them in addition to other models.

The third and final European survey[59] aimed to describe the characteristics of programs for VAD patients specifically (and hence is not shown in Table 1). Surveys were completed by 32 phase II programs in VAD centers in 26 countries. Results specified the duration of out-patient CR programs to be between 4-12 weeks. CR teams were composed of physiotherapists (73%), psychologists (51%), nurses (49%), specialized cardiologists (49%) and dietitians (47%). The exercise component of many programs included exercise training (84%), respiratory muscle training (55%), and resistance training (49%). Alternative models were offered, mostly home-based (9%).

The survey in Denmark[60] was completed by 44 phase II CR programs. CR teams were also composed of nurses and physicians. The core component that was also offered in many programs was smoking cessation (71%).

Two surveys were conducted in Italy. In the first[61], in addition to those shown in Table 1, other healthcare professionals on CR teams were psychologists (74%) and dietitians (62%). Sixty-eight percent of phase II programs were residential. The mean length of stay for these programs was 18.5 days. Results of the second survey[31] were reported in an English-language abstract. The survey was completed by 102 phase II programs. Over 75% of programs were headed by a cardiologist. In terms of alternative models, 8% offered tele-rehab and 5% offered home-based CR.

Three surveys were conducted in Portugal. In the first[62], in addition to those noted in Table 1, CR teams also included physiatrists (61%), and psychologists (61%). In the second[63], findings indicated that in addition to the healthcare providers shown in Table 1, again physiatrists (75%) and psychologists (62%) were also included as part of the CR team. In the most recent survey[64], again physiatrists (74%) and psychologists (61%) were also included as part of the CR team. The core components that were also offered in most programs were dietary counseling (96%), and smoking cessation (96%).

In the survey conducted in Spain[65], in addition to those shown in Table 1, occupational therapy (9%) was offered as part of the CR program. In addition to the major diagnoses accepted shown in Table 1, patients with valvular surgery (73%) and with heart failure (64%) were also included. Barriers to CR creation (not delivery as shown in the Table) included lack of support from administration (72.7%), lack of patient information/ patient skepticism (54.5%), and lack of staff interest (45.5%).

Finally, for Europe, 2 descriptive studies were also identified. In the Swiss paper[36], 57 phase II CR programs were identified. CR teams were composed of cardiologists, physiotherapists, nurses, dietitians, psychologists, occupational therapists and social workers. In the German paper[39], coverage for phase II CR by government for all MI patients, and following CABG and valvular surgeries was described. Phase II programs were delivered in inpatient and outpatient settings, where both are 3 weeks long and are delivered by a multidisciplinary team including physicians, nurses, exercise specialists, physiotherapists and nutritionists.

Six surveys were conducted in the United Kingdom. In the first survey[66] which was conducted throughout the 4 countries, findings indicated that, in addition to the top 3 healthcare professions shown in Table 1, CR teams also included occupational therapists (40%) and physicians (39%). In the second survey[67] conducted in England and Wales, findings indicated the mean exercise session duration was 55 minutes. There were 7 major public funding bodies reported which reimbursed CR services, but for 7 (28%) programs funding source was unknown. In addition to the healthcare professionals shown in Table 1, CR teams also included dietitians (8%), psychologists (4%) and exercise physiologists (4%). Counselling (40%) was also offered as a component of CR programs.

In the survey conducted in England only[68], results showed that the mean exercise session duration was 60 minutes. In addition to those shown in Table 1, other healthcare professionals on the teams were pharmacists, occupational therapists and psychologists.

In the survey conducted in Ireland only[69], results showed that 21 of 53 (40%) hospitals had a CR program (of which 12 were in the Republic of Ireland, with the remainder in Northern Ireland). Other healthcare professionals delivering CR were physiotherapists and ECG technicians. Other components offered included smoking cessation, medication advice as well as

sexual and vocational counselling. In addition, the study in Northern Ireland[70] showed that few centers (13%) accepted patients with valvular disease, heart failure, angina, or PCI.

Finally, for the United Kingdom, a survey was conducted in Scotland[71]. Findings indicated programs were only available in 7% of hospitals. As well as the major diagnoses accepted in CR programs shown in Table 1, patients suffering from heart failure (35%) were also accepted. Another major barrier to patient participation identified was transportation issues (49%).

CR Delivery in Latin America and the Caribbean

As shown in Table 1, there have been 3 studies in this region, representing CR in the following 11 countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela (11 [26%] of 42 countries; 9 [35%] of 26 LMICs in the region). One English-language abstract was identified from Chile[29].

In the survey conducted in Latin America and the Caribbean,[72] in addition to those shown in Table 1, CR teams were also composed of nurses (52%), psychologists (48%), and social workers (33%). As well as the major diagnoses accepted in CR programs shown in Table 1, patients with valvular conditions (82%), heart failure (73%) and heart transplants (21%) were also accepted.

In the survey in South America[73], in addition to the healthcare providers listed in Table 1, many CR teams also included psychologists (53%), nurses (50%), and sport physicians (32%). Psychological counseling (68%) and smoking cessation (59%) were also provided as core components in most programs. As well as the major diagnoses accepted in CR programs shown in Table 1, patients with heart failure (97%) and valvular disease (95%) were also accepted. Notably, the main perceived barrier to CR participation was lack of patient referral (70%).

Two surveys were conducted in Mexico. In the first[74], findings revealed CR teams were also composed of nurses (79. %), nutritionists (79%) and psychologists/psychiatrists (71%). In addition to those shown in Table 1, programs also accepted patients with CABG (87%) and valvular disease (83%). Other barriers to CR cited included lack of space (42%), and a reduction in operating centers (38%).

An English-language abstract was identified from a survey conducted in Chile[29,75]. The survey was completed by 7 (87%) phase II programs. Findings indicated that CR teams were mainly composed of cardiologists, nurses, physiotherapists and nutritionists. All programs included initial assessment, physical activity counseling, and dietary counseling. The major barrier reported was a lack of patient referral.

There have been 2 narrative reviews in Latin America[43,47]. The review in Latin America[43] showed that the source of CR funding across this region was highly variable. Only 4 countries offered 100% coverage through the national health system, while patients paid for most programs out-of-pocket. Core components commonly available included exercise training, risk factor management, and patient education. Major barriers described included poor physician referral, distance to CR center, lack of finances and lack of trained personnel.

Finally, the narrative review in Brazil[47] indicated that the duration of Phase II CR was between 3-6 months, with many programs allowing patients to stay longer. Exercise sessions were typically offered 3 times/week for 55 minutes. Most programs were comprised of an interdisciplinary team including physicians, physical educators, physiotherapists, psychologists and nutritionists. The major barrier to CR access was funding, as CR is more available to patients with the means to pay or who have insurance. Another barrier was that CR was mainly located in large urban centers.

CR Delivery in the Middle East and North Africa

As shown in Table 1, there has been 1 study in this region[24], reporting on CR services in Bahrain, Egypt, Qatar and the United Arab Emirates (4 [19%] of 21 countries; 1 [8%] of 13 LMICs in the region). The survey was completed by 5 (62%) phase II CR programs. Results indicated that, along with those shown in Table 1, CR teams included social workers (20%), and exercise specialists (20%). Nutrition counselling (80%) and prescription or titration of secondary prevention medications (80%) were also offered in most CR programs. The major barriers (reported on a 5-point scale, with higher scores indicating greater barriers) also included lack of financial resources (3.6) and equipment (3.6).

CR Delivery in North America

As shown in Table 1, there have been 7 studies in this region, from Canada, its province of Ontario, and the United States, including in the states of New York, North Carolina and Ohio (2 [67%] of 3 countries; all high-income). In the national Canadian study[24], alongside those presented in Table 1, CR teams also included kinesiologists (35%) and dietitians (12%). All programs also offered nutrition counselling (100%) and physical activity counselling (100%) as core components of the program. Major barriers (again reported on the same 5-point scale as per above) also included patient referral (3.2), and lack of equipment (2.7). In the provincial survey[76], results showed that in addition to those shown in Table 1, 68% of programs also offered psychosocial services. There were also 2 narrative reviews published describing CR status in Canada[42,77].

The two surveys conducted in the United States and the 3 surveys conducted in the individual states of New York, North Carolina, and Ohio are shown in Table 1[48,78–81]. Finally, a

narrative review describing CR in the United States[45] listed lack of patient referral and distance to CR programs as major barriers to CR participation.

CR Delivery in South Asia

A narrative review was published describing CR in India[46]. The publication showed that there are less than 50 programs in the entire country. Programs are delivered by physiotherapists, physicians, dietitians and nurses. Alongside exercise training, many programs in India include yoga as component of CR. The major barriers to CR were distance from the CR center and lack of transportation.

DISCUSSION

Through this review, the nature of CR services in less than half of countries offering CR around the globe was characterized. This first-ever such study sheds light on variation in quality and nature of CR globally. Clearly evidence-based practices should be applied consistently globally, but tailoring to local health systems and patient needs is required. Arguably many of the recommendations in CR guidelines are consensus rather than evidence-based however. Regardless, the results herein for the first time characterize how CR is delivered in relation to established standards[13,14,18,27].

Most programs were funded publicly (73% of studies reporting funding source). This is positive, considering previous research has shown that more sessions are funded where programs are funded publicly[82]. Regionally, in Europe and Central Asia CR was more commonly reimbursed through a national health service, while in the rest of the world private systems may play a more important role (e.g., United States, Middle East and North Africa). While this review shed light on CR reimbursement and variation in these sources, more information regarding CR delivery costs to the healthcare system and to patients would be informative.

Where reported, MI was the diagnosis most frequently-accepted in Europe and Central Asia, compared to PCI in Eastern Asia and Pacific, as well as Latin America and the Caribbean. Clearly, there is excellent evidence supporting the benefits of CR for acute coronary syndrome and associated revascularization. There is now growing evidence supporting the benefits of CR for arrhythmia patients[83,84], those with valve disorders[85], and heart failure[86–88]. With regard to the former, atrial fibrillation was not mentioned as an indication in any study (this could be due to recency of evidence regarding the benefits of exercise in this population), however rhythm devices were stated as an indication in many European countries (i.e., Austria, Belarus, Belgium, Croatia, Cyprus, Czech Republic, Denmark, England, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Norway, Northern Ireland, Poland, Portugal, Romania, Russia, Serbia, Slovak Republic, Scotland, Spain, Sweden, Switzerland, Wales) and also Mexico for example. Valve disorders / procedures were also recognized indications in many European (Austria, Belarus, Belgium, Croatia, Cyprus, Czech Republic, Denmark, England, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Norway, Northern Ireland, Poland, Portugal, Romania, Russia, Serbia, Slovak Republic, Scotland, Spain, Sweden, Switzerland, Wales, Singapore, and Spain) as well as South American (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, Uruguay, Venezuela) countries. A very similar list of countries also accepted HF patients. Thus, it seems CR programs have the capacity and expertise to adapt to new evidence, and accordingly change their policies regarding patient indications for admission.

In the 7 (30%) studies reporting capacity, the number of patients served per program ranged from 129-639, with a median of 202. This appeared higher in Europe than North America. The impact of patient volume on CR care quality appears irrelevant based on early

work on this question from the United Kingdom[89], but research has suggested higher volume acute cardiac care centres have better outcomes than lower-volume ones[90]. The number of patients served per country was also reported in some instances, and data confirmed the gross under-capacity established in other work[91].

When comparing by region, considerable comparability in CR staff composition was observed. In almost all studies (n=21, 72%), programs were delivered by a multidisciplinary team. The most common types of healthcare providers were physicians, nurses and physiotherapists. While there is not necessarily an evidence base to support recommendations that CR programs be staffed by an inter-professional team, this certainly supports competent delivery of all recommended core components needed to optimize secondary prevention. Contrary to some (but not all[20]) guideline recommendations[16,18,15] that CR be directed by physicians however, these providers were only among the top three most frequent personnel in the Middle East and North Africa, Latin America and the Caribbean, Europe as well Central Asia (but not in East Asia, the Pacific, and North America). Also interestingly, in some regions physiotherapists were a main part of the team (n=17 of 21 papers reporting staff composition, e.g., Australia, England, Scotland, Northern Ireland, Wales, Denmark, Italy, Portugal, Spain, Mexico, Bahrain, Egypt, Qatar, UAE and Canada; e.g.,[24,61,66,92]), whereas in others, exercise specialists were more common (i.e., exercise physiologists, kinesiologists; n=7 of 21 papers reporting staff composition; North America, China and the Middle East; e.g.,[24,93]). Whether this is a function of availability of training programs and hence staff to hire, reimbursement policies in the healthcare system, costs to programs, or other factors is unknown, as is the impact for patient outcomes (although there is no basis on which to assume different outcomes would be observed).

There is no evidence to our knowledge on which to base clinical practice recommendations regarding number of CR sessions, or dose, to prescribe. A previous review of clinical practice guidelines revealed broad variability in recommendations internationally[20], as did a review of primary studies by our group[94]. The range of sessions prescribed spanned from a minimum of 16.5±2.1 sessions in France, to a maximum of 142.0±112.4 sessions in Spain. Herein, dose (both program duration and session frequency) was only reported in 12 (41%) studies, and ranged from 6 (New Zealand) to 44 (Canada), with a median of 20. The variability is postulated to be based on reimbursement policies. Clearly, evidence is needed to demarcate minimum dose of CR needed to significantly improve patient quality and quantity of life, with consideration of case-mix[95], so quality of care in countries/regions not meeting this minimum can be improved.

With regard to core components delivered, exercise training was the most consistently offered one overall, but also in the regions of Europe and Latin America; this is laudable given that the greatest improvements in prognosis are explained by improvements in cardiorespiratory fitness achieved through physical activity[96-99]. Clearly great efforts are needed to increase CR penetration in healthcare systems across the globe, given these are highly cost-effective strategies[100-103]. The next most commonly-offered component was patient education, which was delivered particularly often in North America, as well as the Middle East and North Africa. Dietary counseling was particularly common in Eastern Asia and Pacific, which is reflected in the high prevalence of dietitians on their CR teams in this region. Overall results suggest most programs globally offer the main core components, however clearly the results herein are only generalizable to the primarily high-income countries represented (Figure 1).

Due to the challenges of delivering supervised CR in the clinical setting to all patients in need, alternative models such as home-based and community-based programs have been developed, which arguably may have broader reach. They are also shown to be efficacious[104–107]. The offering of alternative models was first reported in a 1997 publication from England and Wales[25]. The degree of implementation of these alternative models is shown to be incredibly low globally through this review. Where reported, home-based CR was offered by a median of 15% of programs, community-based CR by 24% of programs, and internet or other technologically-based CR by 11% of programs. In the Middle East and North Africa, CR is not available outside a clinical center[24]. Further research on the comprehensiveness and nature of alternative models is needed to understand whether CR standards are being met in non-supervised settings. In addition, we must apply tools from implementation science to ensure these alternative models are available to patients who cannot access, or for whom there is no space, at a supervised program (and arguably even those who only prefer to undertake CR independently, so CR is patient-centered).

On a related note, through this review it was identified that phase II CR is offered in residential settings in the following countries: Austria, Belarus, Croatia, Czech Republic, Finland, France, Germany, Hungary, Iceland, Italy, Lithuania, the Netherlands, Romania, Russia, Serbia, and Spain. Again, it is suspected that this is a function of historic practice and reimbursement policies rather than evidence. To our knowledge, the effect on care quality, patient satisfaction and outcomes as well as long-term maintenance of heart-health behaviors has not been established; this represents an important area for future study.

The most commonly-reported barrier to CR delivery around the globe was lack of resources. This was the most consistent finding across all studies. It continues to be baffling that

a Class I, Level A recommendation in applicable clinical practice guidelines around the globe[9,10,108] is under-resourced, when compared to other similarly-graded recommendations for the same indications. The cardiac community (including societies, foundations, and governments) must continue to advocate for CR reimbursement[82]. Indeed, the International Council of Cardiovascular Prevention and Rehabilitation has recently developed and collated resources to achieve this aim (see: http://globalcardiacrehab.com/advocacy/). On a final note, lack of referral was also noted as a significant barrier in many studies.

Through this review, several areas where further research is urgently needed have been identified. First, there is little information on the nature of CR in the following regions, which also have among the highest burdens of CVD: East Asia, the Pacific, the Middle East, North Africa, Sub-Saharan Africa and South Asia (Figure 1). Specifically, in East Asia and the Pacific there are 38 countries, of which we perceive 15 have CR, however services are only characterized in 4 of these countries. There are 21 countries in the Middle East and North Africa, of which we perceive 12 have CR, and services are only characterized in 4. In Sub-Saharan Africa there are 48 countries, of which we perceive 7 have CR, and services have never been characterized. Similarly, South Asia includes 8 countries, of which we perceive 5 have CR, yet CR has also never been characterized there. Second, while number of centers and center capacity was reported in many of the papers, given that this was not reported consistently, the number of countries not represented, the low response rates, and that capacity was not juxtaposed against CVD burden, firm conclusions regarding CR availability and capacity should not be drawn from this work. More comprehensive, but gross, information on this is reported elsewhere[21,91]. More information on CR density globally is needed. Finally, the way the constructs under investigation in this study were measured was not consistent across studies, and

therefore some caution in interpreting the comparisons made across studies herein is warranted. Administering a standardized and validated set of survey items in all countries would address this limitation. Our group is currently performing this.

Caution is warranted in interpreting these results. First, the search was not systematic and only English-language publications were included, so some studies might have been missed, along with grey literature. Second, in many cases, respondents' estimates of characteristics and delivery of CR programs were reported, and hence values should be interpreted with caution. Finally, generalizability is limited in several ways. Surveys of CR programs have only been undertaken in half of the countries where it is suspected to be offered. Moreover, better-resourced countries (and perhaps even programs) are represented in the surveys (Figure 1), and thus this characterization of CR services likely reflects higher-quality care than is the norm. As a final point, the response rate was low in some studies (n=3, 16% <40%)[24,48,78], and not reported in many others (n=6, 21%)[55,53,60,69,72,73], and hence caution is warranted in generalizing results from those studies in particular.

In conclusion, while the CVD burden and associated death rates are increasing, and CR is recognized as one of the most beneficial and cost-effective mitigation strategies, information about the nature and quality of CR services is only available for about half of countries globally where it is believed to be offered. This review has demonstrated that CR is most often reimbursed by public sources, is most-commonly offered to MI patients with revascularization, with the average program serving ~200 such patients, by a multi-disciplinary team most-frequently comprised of physicians, nurses and physiotherapists. Most programs deliver the major core components, most-commonly exercise training, patient education and nutrition counselling, over a median of 20 sessions (2 sessions/week over 9 weeks). A consequent

observation from the review is the lack of CR density, due to lack of human and financial resources as well as space, consistent with previous reviews, but has also for the first time quantified the dearth of delivery of CR in alternate settings globally. This represents an important means to increase reach of CR. Documentation of CR delivery variation can be used to support meeting of minimum standards by all countries.

Statement of Conflict of Interest

All authors declare that there are no conflicts of interest.

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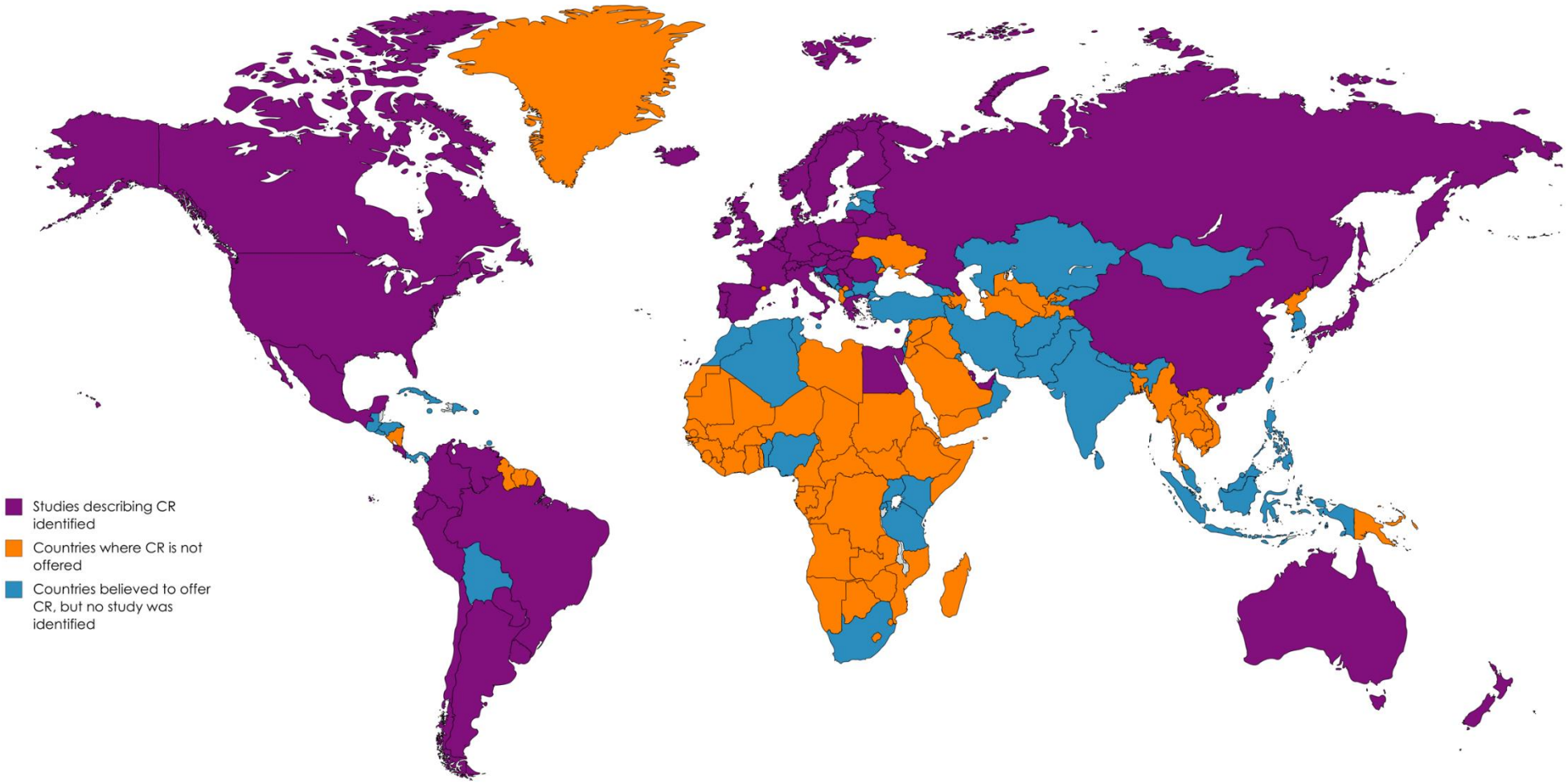
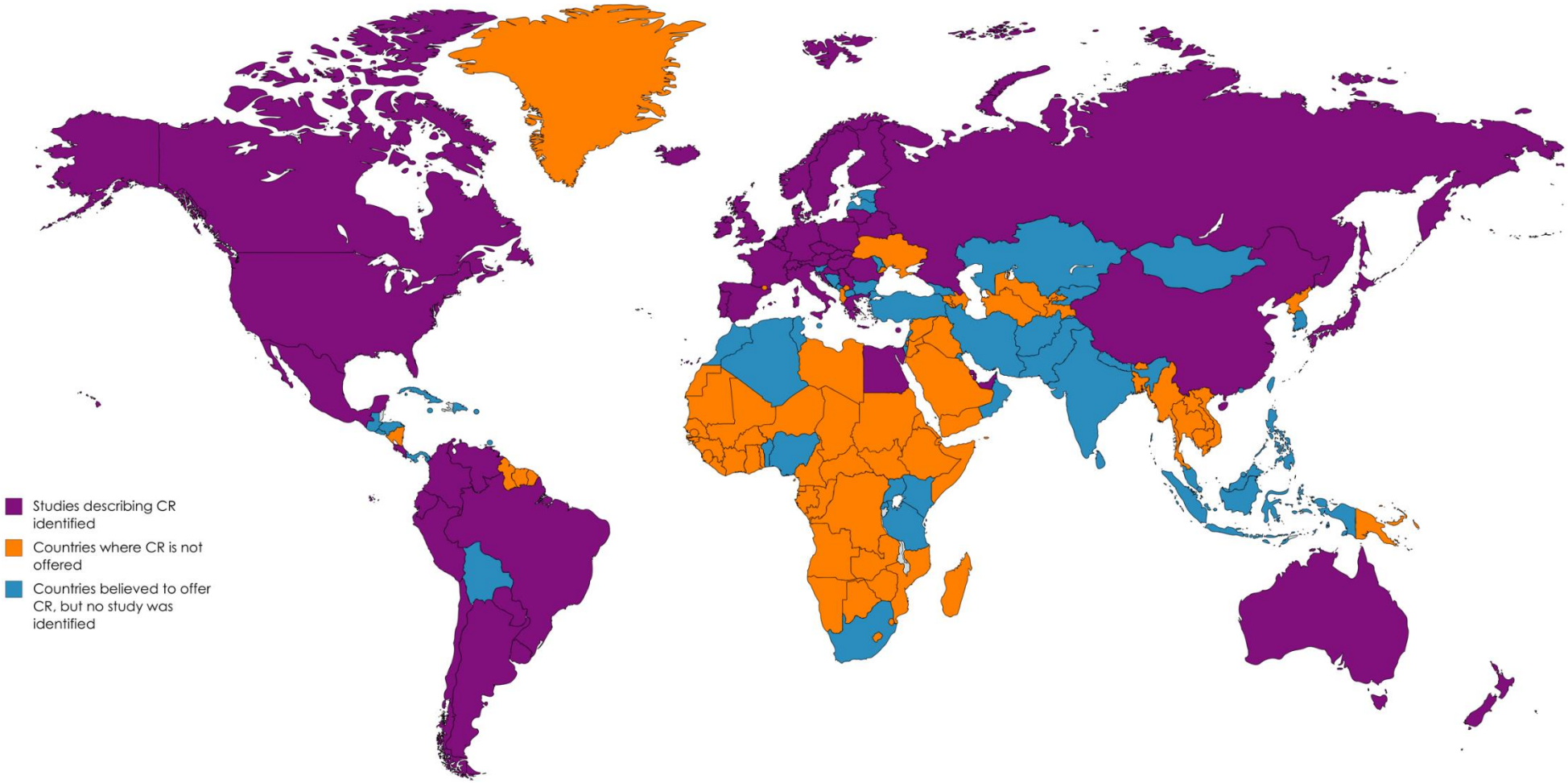
Figure 1. World Map Depicting Countries Where Surveys of Cardiac Rehabilitation Programs Have Been Undertaken





CR = Cardiac Rehabilitation

Table 1: Summary of Findings – Results from National/Regional Surveys of CR Programs, N=28

	Results								
Country (year of publication)	Number of Respondents/ number of CR Centers (response rate %)	Reimbursement Source[§‡]	Patient diagnoses accepted[‡] (% of programs)	Patients Served[§] per program or ***country per year***	Staff Composition[‡] (% of programs)	Dose[§] (weeks x frequency/week)	Core Components Delivered[‡] (% of programs)	Alternate Models (% yes)	Barriers[‡] (% of programs)
East Asia and the Pacific									
Australia[50] (2016)	225/305 (74%)	Public (68%) Private (13%) Patient (14%)	MI (100%) CABG (100%) PCI (100%)	250	Nurses (88%) Dietitians (82%) Physiotherapists (77%)	11 (7 x 1.6)	ET (100%) PE (98%) NC (88%)	CB (18%) HB (15%)	-

China[53] (2016)	10/ -	-	PCI (100%) HF (100%) MI (92%)	-	Physicians (100%) Nurses (85%) Dietitians (46%)	-	IA (100%) PE (100%) NC (100%)	-	Interest in CR (58%) HR (58%) PAW (50%)
Japan[55] (2007)	52/ -	Public (100%)	-	***4,896***	-	-		-	HR (77%) EQ (41%) Achieving facility standards (31%)
New Zealand[52] (2016)	34/46 (74%)	-	-	-	-	6 (6 x 1)	ET (100%) RF (100%) NC (100%)	CB (62%) HB (12%)	-
Regional Summary: Mean (Median)	**74% (74%)**	**Public; 84% (84%)**	**PCI: 100% (100%) MI: 96% (96%)**	~	**Nurses: 87% (87%) Dietitians: 64% (64%)**	**8.6 (8.6)** **(6.5 [6.5], x 1.3 [1.3])**	**ET: 100% (100%) NC: 96% (100%) PE: 99% (99%)**	**CB: 40% (40%) HB: 14% (14%)**	**HR: 68% (68%)**
Europe and Central Asia									

Europe[58] (2002)- 13 countries	252/443 (57%)	-	-	-	Physiotherapists (90%)¶ Nurses (87%)¶ Cardiologists (82%)¶	- (8.4 x -)	ET (95%)¶ NC (90%)¶ SC (70%)¶	-	-
Europe[23] (2010)- 28 countries	28/39* (72%)	Public (89%) Private (39%)	CABG (86%) MI (82%) Valve (60%)	-	-	- (9 x -)	-	HB (28%)	-
United Kingdom[66] (1998)	263/273 (96%)	-	-	-	Nurses (89%) Physiotherapists (85%) Dietitians (84%)	-	-	-	-
England & Wales[67] (1997)	22/25** (88%)	Public (56%)	-	166 ***3,813***	Nurses (100%)¶ Physiotherapists (88%)¶ Physicians (16%)¶	11 (7 x 1.5)	ET (100%) PE (100%) SM (96%)	CB (4%) HB (4%)	-
Denmark[60] (2005)	44/ -	-	MI (100%) IHD (81%) HF (75%)	-	Physiotherapists (100%) Dietitians (89%)	-	NC (89%) ET (77%) SM (71%)	-	-
England[26] (2006)	28/28** (100%)	-	MI (100%) CABG (100%)	-	Nurses (100%) Physiotherapists (90%) Dietitians (90%)	14 (7 x 2)	ET (100%) PE (100%) SM (100%)	HB (36%) CB (21%)	-
Ireland[69] (2001)	21/- (81%)	Patients (14%)	-	-	Coordinators, Nurses, Dietitians	14 (8 x 1.7)	ET, PE, SM	-	PR

N. Ireland [70](1997)	8/9 (89%)	-	MI (100%) CABG (88%) HF (13%)	-	-	6 (6 x 1)	-	-	-
Italy[61] (2008)	51/65 (78%)	Public (99%)	-	-	Physicians (100%) Nurses (90%) Physiotherapists (84%)	- (12.5 x -)	-	HB (10%)	-
Portugal[62] (2007)	12/12 (100%)	Public (51%) Patients (-)	-	-	Cardiologists (100%) Nutritionists (92%) Physiotherapists (85%)	-	-	-	-
Portugal[63] (2010)	14/14 (100%)	Public (82%) Patient (8%)	-	-	Cardiologists (100%) Physiotherapists (88%) Nutritionists (81%)	-	ET (100%) RF (75% SM (25%)	-	-
Portugal[64] (2016)	19/19 (100%)	Public (90%) Patient (5%)	-	***1,927***	Cardiologists (100%) Nutritionists (87%) Physiotherapists (87%)	25 (10 x 2.5)	ET (100%) RF (96%) NC (96%)	-	-
Scotland[71] (1996)	69/69 (100%)	Public (50%)	MI (96%) PCI (81%) Angina (70%)	***4,980***	-	-	-	-	Resources (46%)

Spain[65] (2003)	11/12 (92%)	-	MI (100%) PCI (100%) CABG (91%)	639	Physiotherapists (100%) Nurses (100%) Cardiologists (82%)	30 (10 x 3)	PE (100%) ET (73%) SM (55%)	-	AS (73%) PAW (55%) Resources (55%)
Summary: Mean (Median)	**89% (96%)**	**Public: 74% (82%)**	**MI: 96% (100%) CABG: 91% (90%) PCI: 91% (91%)**	**402 (402)** ***3,573 (3,573)***	**Nurses: 94% (94%) Physiotherapists: 90% (88%) Physicians: 83% (100%)**	**17 (14) (9 [9] x 2 [2])**	**PE 100% (100%) ET 92% (100%) SM 70% (71%)**	**HB: 19% (19%) CB: 12% (12%)**	**~**
Latin America and the Caribbean									
Latin America and the Caribbean[72] (2009)- 9 countries	33/ -	Public (48%) Private (24%) Patients (-)	MI (100%) PCI (97%) CABG (97%)	-	Cardiologists (100%) Physiotherapists (94%) Dietitians (91%)	33 (13 x 2.5)	-	CB (48%)	HR (41%) FR (33%) Space (13.0%)
South America[73] (2013) -9 countries	107/ -	Mixed (46%) Private (19%) Patient (18%)	MI (100%) PCI (99%) CABG (97%)	180	Cardiologists (85%) Nutritionists (72%) Physiotherapists (72%)	-	ET (97%) RF (96%) NC (91%)	-	FR (13%) TI (13.0%) Space (6%)

Mexico[74] (2016)	24/24 (100%)	-	IHD (100%) PCI (100%) HF (92%)	-	Physicians (100%) Administrative assistants (100%) Physiotherapists (83%)	-	ET (100%) NC (90%) SM (80%)	HB (37.5%)	FR (83%) HR (67%) EQ (46%)
Summary Mean (Median)	~	**Private: 21% (21%)**	**MI: 100% (100%) PCI: 99% (99%) CABG: 97% (97%)**	~	**Physicians: 95% (100%) Dietitians: 81% (81%)**	~	**ET: 98% (98%) NC: 90% (90%)**	~	**HR: 54% (54%) FR: 58% (58%) Space: 9% (9%)**
Middle East and North Africa									
Arab Countries[24] (2015) - 4 countries	5/8 (63%)	Public (40%) Private (40%)	-	224	Nurses (60%) Cardiologists (40%) Physiotherapists (20%)	25 (11 x 2.3)	PE (100%) IA (80%) ET (80%)	Not offered	PR (60%) Space (50%) HR (50%)
North America									
Canada[24] (2015)	39/128 (31%)	Public (100%) Patients (34%)	-	512	Nurses (56%) Exercise specialists (38%) Physiotherapists (35%)	41 (18 x 2.3)	PE (100%) NC (100%) ET (100%)	CB (28%) HB (3%)	FR (62% HR (34%) Space (22%)

Ontario, Canada[76] (2012)	38/45 (84%)	-	-	-	-	44 (22 x 2)	PE (97%) ET (97%) RF (92%)	HB (68%) IB (11%)	-
United States[48] (2013)	137/1000 (14%)	-	-	129 ***19,689***	Nurses (38%) Exercise specialists (28%) Respiratory therapists (10%)	-	PE (100%)	-	-
United States[78] (2014)	281/823 (34%)	-	-	165 ***41,525***	-	-	-	-	-
New York, United States[79] (1990)	16/24 (67%)	Patients (-)	-	-	Exercise specialists (90%) Physicians (69%) Physiotherapists (25%)	-	ET (100%) PE (55%) RF (45%)	-	-
North Carolina, United States[80] (2006)	61/77 (79%)	-	-	-	Nurses (97%) Exercise specialists (87%) Dietitians (84%)	-	SM (100%) NC (100%) ET (97%)	-	-

Ohio, United States[81] (2012)	94/142 (66%)	-	-	-	Exercise specialists (73%)		ET (97%) NC (97%) SC (88%)	-	-
Summary Mean (Median)	**41% (32%)**	**~**	**~**	**269 (165)** ***30,607 (30,607)***	**Nurses; 70% (73%) Exercise specialists: 57% (56%) Physiotherapists: 30 (30)**	**42 (42) (20 [20] x 2 [2])**	**ET: 98% (97%) PE: 88% (99%) NC: 99% (100%)**	**HB: 35% (35%)**	**~**
Overall Summary Mean (Median)	**76% (79%)**	**Public: 73% (75%) Private: 27% (24%) Patient: 26% (26%)**	**MI: 97% (100%) PCI: 97% (100%) CABG: 94% (97%)**	**283 (202)** ***12,805 (4,938)***	**Physicians: 84% (100%) Nurses; 81% (88%) Physiotherapists 89% (85%)**	**22 (20) (10 [9] x 2 [2])**	**ET: 95% (99%) PE: 95% (100%) NC: 95% (96%)**	**CB: 30% (24%); HB: 24% (15%)**	**HR: 53% (52%) FR: 47% (46) Space: 23% (17%)**

‡Only the top 3 reported are listed
§If only a range was provided, the midpoint of ranges is reported; if multiple ranges reported, the one with the highest percentage was reported.
¶Value based on approximation from figure. Author contacted to request actual values, but no response
*number of countries (1 survey was filled out per country)
** Only sub-sample of entire population surveyed
(-) Article did not report
~ Unable to compute

CABG = coronary artery bypass graft; HF = Heart failure; IHD = ischemic heart disease; MI = myocardial infarction; PCI = percutaneous coronary intervention; VAD = ventricular assist device

CB = community-based; HB = home-based; IB = internet-based (or other form of technology).

IA = initial assessment; ET = exercise training; RF = risk factor management (which in some instances may include smoking); PE = Patient education; NC = nutrition counseling; SC = smoking cessation; SM = stress management and/or psychosocial support/counselling.

AS= administrative support; EQ= equipment; FR= financial resources; HR= human resources; PAW= patient awareness; PR= patient referral; TI = transportation issues