Cardiac Rehabilitation Delivery in Low and Middle-Income Countries

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Abstract

Cardiovascular diseases are among the leading causes of disability in low- and middle-income countries (LMICs). Cardiac rehabilitation (CR) is an effective secondary prevention program model. In this cross-sectional study, a confidential, online survey was administered to CR programs around the world. CR programs were identified in 55/138 (39.9%) LMICs; 47 (85.5% country response rate) countries participated and 335(53.5% program response rate) surveys were initiated. There was 1 CR spot for every 66 incident ischemic heart disease patients in LMICs. CR was most often paid by patients in LMICs (n=212,65.0%). On average, programs offered 7.3±1.8/11 core components over 33.7±30.7 sessions (significantly greater in publicly-funded programs;p<.001). Lack of patient referral (3.8/5) and financial resources (3.5/5) were the greatest barriers to CR provision in LMICs. CR is only available in 40% of LMICs, but where offered is fairly consistent with CR guidelines. Governments must enact policies to reimburse CR so patients do not pay out-of-pocket.

Dedication

I would like to dedicate this to my friends, family and mentors, without their support and encouragement I would not have come this far.

Acknowledgments

I would like to first and foremost thank my supervisor Dr. Sherry Grace, for the tremendous opportunity and all the support and guidance during the past 2 years. In addition, I would also like to thank my thesis committee member, Dr. Paul Oh for his encouragement and expertise. Finally, I would like to thank my co-investigators from the global CR survey team and my colleagues for their kind and endless support.

Attestation

Pesah E

Cardiac Rehabilitation Delivery in Low- and Middle-Income Countries.

This letter attests that the candidate: (1) undertook a literature review of previous national and international surveys of CR programs; (2) supported data collection through management of the master MS Excel file of countries with CR where contact with societies, responses, and timing of survey administration is tracked; (3) searched for individual program email addresses where required; and (4) created and provided the feedback summaries to all study participants and participating national societies. Finally, the candidate (5) undertook the statistical analysis of the data for her thesis, and (6) drafted the thesis manuscript.

Signature on file. March 29, 2018

Sherry Grace Date

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INTRODUCTION

Cardiac rehabilitation (CR) is an essential part of the continuum of care for patients with cardiovascular disease (CVD), given the well-established benefits of participation[1]. CR is offered in 83 out of the 196 countries around the globe[2]. Provision at the national level have been well described in published survey results in Europe, as well as in North America. Standards for CR delivery have also been established on these continents[3–7] .

Cardiac rehabilitation (CR) is a proven model of care for secondary prevention. It is comprised of several core components, delivered by a multi-disciplinary team.[8,9] Participation in CR reduces CVD mortality and hospital re-admission by approximately 20%, as well as improves quality of life,[10] with more CR associated with better outcomes. Accordingly, it is a recommendation in clinical practice guidelines for CVD,[11] revascularization,[12,13] and heart failure (HF)[14] patients, with robust evidence of benefit also in valve patients,[15] transplant,[16] and atrial fibrillation.[17]

In low and middle-income countries (LMICs) where the epidemic of CVD is at its worst, little is known about the availability of CR and the models for its delivery[2,18]. In the few available publications regarding CR in LMICs, results revealed variability in the source of funding and delivery of core components, however major barriers such as lack of human/financial resources were comparable across settings[19–22]. There are also major geographic disparities in the publications with the majority of studies from Europe and South America and little data from Asia and Africa. Clearly, little is known about CR delivery in these countries heavily burdened by CVD. The purpose of this thesis is to characterize the nature of CR in LMICs, as well as the barriers to delivery to inform policy and strategies to broaden delivery.

LITERATURE REVIEW

Cardiovascular disease (CVD) refers to a class of diseases that involve the heart or blood vessels. CVD is the leading cause of death globally, with over 17 million deaths annually[23]. At the same time, with the advancements in medical technology, more patients are surviving cardiac events--however these patients are at a higher risk of another event[24]. Moreover, CVD is among the leading causes of disability around the world [25]. The number of people living with chronic CVD is increasing and it now contributes to 10% of disability adjusted life years (DALYs) lost world-wide [26]. CVD imposes a huge economic burden on health systems as a result of the direct and indirect costs (cost of health care services, medications, and lost productivity [27]) associated with mortality and morbidity [28]. Clearly there is a great need for effective secondary prevention.

While CVD has historically been a challenge in high-income countries due to factors such as expansion of the fast food industry and greater reliance on sedentary forms of travel, over the past two decades, CVD death rates have increased at an alarming rate in economically-disadvantaged countries, or LMICs. Indeed, with better control of communicable diseases and rapid urbanization in LMICs, more than 80% of the world's CVD deaths now occur in these countries[25].

Countries are classified according to their economy using 2017 Gross National Income (GNI) per capita in United States Dollars (USD) purchasing power parity (PPP), in accordance with World Bank methodology[29]. Low-income countries are those with GNI per capita of $1,025 or less. Lower middle-income countries have a GNI per capita between $1,026 and $4,035 and upper middle-income countries are those with a GNI per capita between $4,036 and $12,475[29]. Of the 196 countries globally, 138 are LMICs: 30 low-income, 53 lower middle-income and 55 upper middle-income.

Cardiac Rehabilitation

CR is a multidisciplinary approach to secondary prevention designed to stabilize, slow, or promote regression of CVD to reduce the risk of a future cardiac event[30]. It is defined by the World Health Organization (WHO) as the "sum of activities required to influence favourably the underlying cause of the disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume when lost, as normal a place as possible in the community"[31]. CR programs offer medical assessment, structured exercise training, patient and family education, and delivery of comprehensive management strategies of CV risk factors (lipids, hypertension, weight, diabetes mellitus, and smoking)[32]. It is recommended CR be initiated before discharge for a cardiac condition (i.e., Phase I), then be offered more comprehensively to outpatients (i.e., Phase II), and that patients maintain their behavior changes long-term (i.e., Phase III).

Many randomized controlled trials and major meta-analyses have shown that participation in CR promotes a healthy lifestyle, reduces risk factors, improves health-related quality of life, and decreases morbidity and mortality by approximately 25% [33–36]. It is a class 1 level A recommendation in clinical practice guidelines for cardiac patients [37–41]. CR is also proven to be a cost-effective secondary prevention strategy[42].

Cardiac Rehabilitation in Low- and Middle-Income Countries

CR is available in 82.4% of high-income countries, but only 53 (50.0%) of MICs and 7 (22.6%) of LICs[2]. Based on this review of the availability of CR globally, and 3 other reviews of CR in LMICs[2,18,43], the 60 LMICs where CR is suspected or known to be offered are shown in Table 1. Using World Bank classifications, there are programs in 6 (75.0%) South Asian LMICs, 8 (16.7%) in Sub-Saharan Africa, 14 (43.8%) in East Asia and Pacific, 45 (80.4%) in Europe and Central Asia, 37 (70.3%) in Latin America and the Caribbean, 14 (66.7%) in the Middle East and

North Africa and 3 (100%) in North America. Clearly, more programs are needed, but we must understand more about the nature of services and barriers to delivery to support broader implementation.

The handful of primary studies on CR benefits from LMICs suggest that positive outcomes are achieved and the magnitude of these benefits are similar to those established in high-income countries[44]. Specifically, participation in CR is associated with significant reduction in triglycerides[45–47], total cholesterol[45–47], LDL[45,47,48], body mass index[46–48], as well as systolic[45,48], and diastolic blood pressure[45]. CR is also associated with significant increases in HDL[47,48]. Additionally, some studies revealed significant improvements in health-related quality of life[49–52], self-efficacy[49], self-regulation[49], and functional capacity[47,48,52]. No studies have assessed mortality or morbidity outcomes in LMICs, but the changes in risk factor profiles and health behaviours have been strongly associated with mortality reductions[53].

To better address the global burden of CVD, CR programs must be universally available and be of high-quality. Consensus guidelines for CR delivery for lower resource settings have been developed for a global perspective[8,9], Europe[54], China (personal communication, R. Ding), and South America[55]. A review of the literature revealed there have been 4 English-language primary studies reporting on the availability and nature of CR services on a national or regional basis in LMICs, reporting on 10 (16.7%) of the LMICs of the world. There was 1 English-language abstract identified from Mexico[56]. While the full publication was not available in English, there were 2 English publications providing some summative views on services there[19,57]. Another survey of CR programs in the Arab world included a response from an Egyptian program[58], but results were not reported separately for this country. There was also 1 paper describing CR in Thailand[21], and another in South America[22]. This covers 11 (18.3%) of

the 60 LMICs where CR is known to be offered. Below these studies are reviewed (by World Bank region), with a corresponding summary of findings shown in Table 2.

CR Delivery in East Asia and the Pacific

As shown in Table 1, there has been 1 primary study in this region, namely in China. One descriptive paper was identified related to Thailand. The survey in China was completed by 13 CR programs, where 10 (76.9%) had comprehensive phase II programs[59]. Findings indicated CR programs were only available in 24.0% of hospitals. CR teams were composed of physicians (100.0%), nurses (84.6%), dietitians (46.2%), clinical educators (30.8%), exercise physiologists (15.4%), and psychologists (15.4%). The core components that were offered in all programs were clinical assessment, physical activity and exercise training counseling, dietary counseling and tobacco cessation interventions. CR programs accepted patients with heart failure (100.0%), post-percutaneous coronary intervention (PCI) (100.0%), post-myocardial infarction (MI) (92.3%), with pacemakers (92.3%) and post-coronary artery bypass graft surgery (CABG) (69.2%). Major barriers to delivering CR were lack of interest (58.0%), human resources (58.0%), awareness (50.0%), and space (47.0%).

The paper describing the status of CR in Thailand reported the existence of 5 programs[21]. Phase was not specified. These programs offered exercise and lifestyle modification. The barriers to patient participation in CR listed were time constraints, transportation, and lack of a caregiver to take them.

CR Delivery in Latin America and the Caribbean

There have been 3 studies in this region, with CR programs surveyed in Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela. All but Chile and Uruguay are LMICs. These are described in turn below.

The first survey conducted in Latin America and the Caribbean was completed by 33 comprehensive phase II programs[19]. Results showed that program duration was between 11 and 15 weeks in most centers (66.0%), and session frequency was mainly 2 to 3 sessions per week (94.0%). Programs served ≤2000 patients per year in 81% of centers, and were funded by hospitals (24.0%), social security (24.0%), and private insurance (24.0%). CR teams were composed of cardiologists (100.0%), physiotherapists (94.0%), dietitians (91.0%), nurses (52.0%) and psychologists (48.0%). Programs accepted patients post-MI (100.0%), post-PCI (97.0%), post-CABG (97.0%), with valvular conditions (82.0%) and heart failure (73.0%). Alternative CR models were offered, most commonly community-based (48.0%). Major barriers to CR implementation were lack of trained personnel (41.0%), lack of funding (33.0%), and lack of space (13.0%).

The second survey in South America was completed by 107 comprehensive phase II CR programs[20]. Findings indicated that CR programs served an average of 180 patients per year and were funded by a mix of sources (46.0%), private insurance (19.0%), patients (18.0%) and hospitals (9.0%). CR teams were composed of cardiologists (100.0%), nutritionists (72.0%), physical therapists (72.0%), psychologists (53%) and nurses (50.0%). Core components that were offered in many phase II programs were physical activity counseling (100.0%), exercise planning (99.0%), exercise training (97.0%), risk factor management (96.0%) and nutrition counseling (91.0%). Programs accepted patients post-MI (100.0%), post-PCI (99.0%), post-CABG (97.0%), with heart failure (97.0%) and with valvular disease (95.0%). Barriers to CR were lack of economic resources (12.8%), lack of space (6.2%), and transportation issues (13.0%).

Two surveys were conducted in Mexico[56,57]. The most recent survey was completed by 24 (100%) phase II programs[57]. Results showed that almost all programs delivered the core CR components, and patients were the main source of funding for CR. Findings indicated that CR teams were mainly composed of physicians (100%), administrative assistants (100%), physical therapists (83.3%), nurses (79.1%) and nutritionists (79.1%). The core components that were offered in many phase II programs were exercise training (100%), dietary counselling (90.0%), and psychological support (80.0%). Programs accepted patients with ischemic heart disease (100%), post-PCI (100%), with heart failure (91.7%), post-CABG (87.5%) and with valvular disease (83.3%). Alternative CR models were offered, most commonly home-based (10.3%). Major barriers indicated were lack of finances (83.0%), lack of trained personnel (67.0%), lack of functional equipment (46.0%), lack of space (42.0%) and a reduction in operating centers (38.0%).

Finally, the narrative review on CR in South America also reported source of reimbursement for services[22]. While there were some publically-funded programs, there were also many privately-run centers. The costs to deliver these were shown to differ. Differences in the nature of the programs that might explain this were not reported.

The survey results reveal: (1) that we do not know about the nature of services in most LMICs, and (2) where it is offered there are some consistencies with CR guidelines and standards[8,9,55]. What is known about CR delivery in LMICs stems from East Asia, Latin America and the Caribbean. There is a major gap in knowledge of CR in LMICs in Europe and Central Asia, Middle East and North Africa, South Asia, and Sub-Saharan Africa. Similarities are seen in the components offered in CR programs, such as physical activity, patient education and nutrition counseling. The health professional most involved in CR delivery were quite

consistently nurses, cardiologists and physiotherapists. Main diagnoses accepted into CR were MI and PCI. The main barrier to CR implementation was lack of financial resources.

Objectives

The aims of this thesis were to assess: (1) availability, volume, capacity and density of CR, (2) nature of CR programs, as well as (3) barriers to CR delivery in LMICs, and compare these (a) to high-income countries (HIC) and (b) by funding source.

METHODS

Design

This thesis was quantitative and cross-sectional in design. Data was gathered form an online survey that was emailed to CR programs identified globally. The study was approved by York University's Office of Research Ethics (Toronto, Canada) and Mayo Clinic's Institutional Review Board (Rochester, United States).

Sample

The sample consisted of all CR programs identified around the world that offered services to outpatients (e.g., Phase II). Only those in LMICs (according to World Bank categorization as outlined above) were used for objectives 1, 2 and 3, while responses were compared to those in high-income countries for objectives 1(a), 2(a), and 3(a). CR programs included were those that offered: (1) initial patient assessment, (2) structured exercise (supervised or not), and (3) at least one other strategy to control risk factors. This included residential programs. Where ≤350 CR CR programs existed in a given country, 250 were randomly selected for inclusion. There were no exclusion criteria.

Individual CR programs were identified on a national basis following a systematic process. First, a MS Excel spreadsheet of countries which offer CR (as identified in previous

reviews[2,18]) was generated. An internet search for CR in all other countries not known to offer CR was performed to ensure the list of countries was current.

Second, through further internet searching of established healthcare societies, national CR associations or organizations were identified for each country known to offer CR. The chair of the society was identified and their email address secured. If no national CR society existed, next Cardiology, then Physical Medicine & Rehabilitation, or "continental" associations of the WHO in the CR field for a given country was identified from peer-reviewed CR literature, the internet or through International Council of Cardiovascular Prevention and Rehabilitation (www.globalcardiacrehab.com) contacts.

Finally, the first key contact for each country was emailed requesting their collaboration in the study. Where ≥10 programs were perceived to exist, the contact was offered co-authorship and provision of comparative country-specific information on CR. Agreeing societies/champions collated email contact information for all known programs in their country, and provided the total number of programs in their country. Where no society or champion were identified in a country where CR exists, individual programs were identified via Google search.

Procedure

The most responsible clinician of the identified CR programs was sent an e-mail requesting her/his participation and a link to the survey. This was sent by the participating society / champion or study investigators, depending on the will of the society / CR champion.

The survey was administered through a web-based program (REDCap). First, informed consent was sought through an online consent form (see appendix A). Respondents were required to click a box to consent, and then they could proceed to complete the survey. The survey was confidential.

Non-respondents were sent 2 follow-up email reminders at 2 week intervals. National CR association representatives / champions were engaged to optimize response rate where below 40%.

Respondents were offered summative feedback on CR delivery in their country in return for their participation. They provided their email address upon completion of the survey if they elected to receive this feedback.

Measures

The CR program survey was developed based on previous national CR surveys developed in Canada and by collaborators [20,58,60–62]. The non-English surveys were translated to English. The investigative team underwent a process of integrating overlapping content, review and approval of a "reference survey". It was pilot-tested in Canada and Arab countries[58]. It was revised based on the pilot test and recent literature, with the final version shown in Appendix B.

The survey was translated into Spanish, Portuguese and traditional Chinese character to facilitate survey comprehension and completion by respondents for whom these are their first-language (funding was not available for further translations).

The survey was composed of open-ended and multiple-choice questions to collect both qualitative and quantitative information. Item 2 was country, which was used to categorize the program as LMIC or HIC (objectives 1[a], 2[a], and 3[a]). As per objective 2, items were designed to assess: (1) location of the program in the healthcare system (items 7-10,15-16); (2) how CR is funded / reimbursed (item 6; for objectives 1[b], 2[b], and 3[b]); (3) program availability, volume, capacity and density (items 12-13; objective 1); (4) healthcare professionals on the CR team (items 18, 24, 38); (5) components delivered (items 20, 23, 27, 39); (6) nature of

patients served (items 28-30); (7) alternative models delivered (section D); and (8) barriers to delivery (item 17; objective 3).

CR program volume was defined as number of patients served annually. Program capacity was defined as the median number of patients a program could serve annually; this was also multiplied by the number of programs in the country (ascertained from champion) to determine national CR capacity. Finally, national density was national capacity divided by 2016 estimated incidence of ischemic heart disease (IHD) (ascertained from Global Burden of Disease study)[63].

Respondents were provided 5 options for funding sources, and instructed to check all that apply. "Other" responses were categorized, and classified as private or public sources (e.g., foundations classified as private). To categorize funding source, respondents that selected the "patient" and/or "private health insurance" options only were categorized as "private"; those that selected the "social security/government" and/or "hospital/clincial center" options only were classified as "public"; those that selected one or more of both the above private and public response options were categorized as "hybrid". National funding source was also computed, classified as the most frequent of the 3 options from all responses in a given country.

Statistical Analysis

Data was analyzed using IBM SPSS 24 and $p<.05$ considered significant. 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. All open-ended responses were coded, using

an interpretive-descriptive approach[64–66]. Google translate was used to translate non-English responses.

To test objective 1, 2 and 3, LMICs were selected and descriptive statistics were used to summarize the closed-ended items (i.e., means and standard deviations, or n and percent).

To test objective 1(a), 2(a) and 3 (a), responses were then compared by economy classification (i.e., LMIC vs high-income country as defined by The World Bank; http://data.worldbank.org/country; independent variable). The nature of CR services and barriers were compared by country income classification and funding source via generalized linear mixed models where possible (treating country as a higher-order variable), otherwise bivariate analyses were computed (e.g., chi-square tests).

Finally, to test objective 1(b), 2(b), and 3(b), responses from LMICs were selected and compared by funding source terms of: capacity, components delivered, dose, health care professionals on the team, alternative models offered, diagnoses accepted and barriers to CR provision. This was undertaken through generalized linear mixed models (treating country as a higher-order variable) where possible.

RESULTS

As shown in Table 3 and Figure 1, 55/138 (39.9%) LMICs in the world were found to offer CR, of which data were collected in 47 (85.5% country response rate). Of these, two (of 5 LICs with CR; 40.0%) were LICs, 15 (of 17; 88.2%) were lower-MICs and 30 (of 33; 90.9%) were upper-MICs. Overall, 335 (53.5% program response rate; shown by income classification in Table 3) surveys were initiated in LMICs, and 747 (27.2% response) in HICs. There was a mean of 6.1±13.3 (standard deviation; median=1) surveys per LMIC. Programs were mainly located in urban areas (n=300, 91.5%).

CR Availability, Volume, Capacity and Density in LMICs

Availability of CR by country is shown in Figure 1 and Table 3. The year the first program was initiated in a LMIC in 1944 in Mexico, and 240 (77.4%) programs in LMICs opened since 2000 (of which 78 were in China). Worldwide, CR exists in 56 (86.2%) of the 67 HICs (this is significantly greater than LMICs; X^2=37.3, p<0.001), 49 (47.1%) of the 108 MICs, and in five (16.7%) of the 30 LICs.

The number of programs per country is shown in Table 3. The median was 3 in LMICs and 15 in HICs (p<0.01). Including countries without CR, there was a median of zero programs/country in LICs, zero programs/country in MICs, and seven programs/country in HICs.

In LMICs, median volume was 110 (Q25-Q75=50-300) patients per program; the median in HICs was 200 (Q25-Q75=120-395; Mann-Whitney U p<0.01).

Programs in LMICs had the capacity to serve a median of 250 patients per program per year (Q25-Q75=100-481); the median in HICs was also 250 (Q25-Q75=183-44; p=0.70). Median national capacity in LICs with CR was 1,575 patients (to be interpreted with caution with only 2 responses), in lower-MICs was 200, in upper-MICs was 1,750 and HICs was 5,739 per year. If we examine median national capacity across all countries of the globe (i.e., N=203; considering none in countries without CR), in LICs this would be zero patients, in MICs zero, and HICs 2,820 patients per year.

National CR density is shown by country in Table 4 (in countries where CR exists; IHD incidence in countries without CR [i.e., no density] is also shown). Results showed wide variability across LMICs, with on average one spot per 52 incident IHD patients (308 in LICs, 274 in lower-MICs and 30 in upper-MICs). Density was greatest in Georgia (one CR spot per two incident IHD patients) and lowest in Nigeria (one spot per 4,480). Median national density in HICs was one spot per five patients. The ranking of countries based on CR density is also

shown in Table 4 (lower scores reflective of better density); of 86 countries with data available, the mean rank for LICs was 66, and 61 for MICs. The top 25 countries were all HICs, except the following three MICs: Georgia (8th), Argentina (17th), and Colombia (22nd). Finally, including LMIC countries without CR, there was on average one CR spot per 66 incident IHD patients. Table 3 also displays unmet CR need.

CR Indications Accepted

Table 5 shows the accepted CR indications by country income classification. The three most commonly-accepted indications (acute coronary syndrome and revascularization patients) were consistent in LMICs and HICs, and with guidelines (HF ~90%). Valve procedures and heart transplant patients were significantly more likely to be accepted by programs in HICs than LMICs, and rheumatic heart disease was more-readily accepted in LMICs.

Three-quarters of programs in LMICs accepted patients at high-risk of CVD or with diabetes as a primary indication (Table 5). Programs in LMICs were significantly more likely to accept these primary diagnoses, as well as patients with lung disease than programs in HICs. Other accepted indications reported by programs in LMICs were syncope (n=19, 29.2%), bariatric/obesity (n=16, 24.6%), and kidney disease (n=7, 10.8%) patients.

CR Providers

The most responsible clinician was some type of physician (e.g., cardiologist, physiatrist, sports medicine) in 254 (81.3%) LMIC programs, and in 428 (63.7%) HIC programs (X^2=31.45, p=<0.001). The most commonly-present HCP type during exercise sessions was physiotherapists (n=185, 72.0%) in LMICs, and in HICs (n=392, 73.3%). The most common HCPs found on CR teams in LMICs were cardiologists, nurses, and physiotherapists; in HICs this was nurses, dietitians, and physiotherapists (Table 6). Two-thirds of programs had an administrative assistant, 57 (19.0%) some form of mental HCP, and one-fifth a community healthcare worker.

Other HCPs on the CR team were physicians of other specialties (n=14, 21.2%), other allied HCP (n=9, 13.6%), and generalist physicians (n=8, 12.1%). CR programs in LMICs were significantly more likely to have physicians on staff, whereas in HICs were significantly more likely to have nurses, dietitians, social workers, pharmacists, and administrative assistants on the CR team than LMICs. Programs on average had six HCPs, with no significant difference by country income classification.

CR Elements

CR elements delivered are shown in Table 7 by country income classification. Initial assessment was the most frequently delivered core component (reflective of inclusion criteria), followed by management of cardiovascular risk factors and patient education in LMICs; this was similar in HICs. Eighty percent of programs offered supervised exercise training. Approximately two-thirds of programs had electronic charting. Initial functional capacity assessment was more commonly by a stress test in LMICs, in HICs other functional capacity tests, such as the 6-minute walk test, were more common. Depression screening, nutrition counseling, stress management, tobacco cessation interventions, return-to-work counselling, and communication with the primary care provider were provided significantly more often by programs in HICs, with a significantly greater number of core components delivered in HICs than LMICs (although programs in LMICs more often offered "other" elements such as family education, and complementary/alternative medicine). Patients were significantly more likely to have an individual consult with a physician in LMICs but with a nurse in HICs. There was more follow-up post-program in LMICs than HICs, and a trend towards more women-only classes (almost one in five programs).

CR Dose

Table 8 shows the greater session frequency, and hence total number of sessions and overall "dose" in CR programs in LMICs and HICs. Median hours / program was 26.5 (Q25-Q75=10-42) in LMICs.

Alternate Models of CR Delivery

Sixty-six (21.5%) programs in LMICs offered an alternative model of CR delivery than supervised clinic-based care, and 219 (36.0%) programs in HICs offered them ($p<0.31$). At a country level, of the 47 LMICs from which data were collected, 22 (46.8%) had at least one program that offered an alternative model (mean=22.7% of programs / country). Home-based programs were the most frequently offered alternative model in LMICs (n=40, 59.7%), followed by community-based (n=20, 29.9%), and hybrid programs (i.e., supervised transitioning to unsupervised; n=20, 29.9%). On average, alternative models were reimbursed by government or insurance in 9% of programs in LMICs, with the highest percentage of programs being reimbursed in Cuba (75.0%)

Barriers to CR Delivery

Respondents were asked to indicate what resources they would need in order to increase capacity for both home-based and community-based programs. Figure 2 summarizes their responses. Home-based programs more commonly required more equipment/ technology for communication while community based programs more commonly required more patient referral/ physician awareness.

Table 9 displays program ratings of barriers to delivery of all models faced by CR programs in LMICs and HICs. The most highly-rated barriers in LMICs were lack of patient referral and financial resources, while financial and human resources were the greatest barriers in HICs. Patient referral was a significantly greater barrier in LMICs. Other barriers indicated by

programs in LMICs were lack of coverage / reimbursement for CR (n=25, 20.0%), transportation / parking / distance (n=24; 19.2%), and lack of patient awareness (n=14; 11.2%).

Costs and Sources of Funding for CR

Respondents were requested to estimate the cost to treat one patient for a full program. Using purchasing power parity conversions (2016 USD)[67], the median cost was $718.24 (Q25-Q75=$337-1,232) in LMICs and $1,267 (Q25-Q75=$581-2,427) in HICs (Mann-Whitney U $p<0.001$).

Figure 1 displays the most common source of funding for CR by country in LMICs. Funding sources in LMICs and HICs are summarized in Table 10 (respondents were instructed to select all that apply). Significantly more programs were funded by patients or private health insurance in LMICs than HICs, with more programs funded by clinical centres in HICs. Other sources of funding were also more common in HICs, which included research funding/universities, veteran programs, and charity foundations.

As shown, patients were the most common CR payers in LMICs, paying some or all of the program cost (mean=49.3±38.4%) in 2/3rds of programs. Using purchasing power parity conversions[67], the median cost to patients for a complete program when they paid was $338.29 (Q25-Q75=$101-814) in LMICs and $244.86 (Q25-Q75=142-596) in HICS (p=0.72; not taking into consideration transportation costs or time off work).

Tables 5-9 display CR program characteristics by funding source in LMICs. As shown in Table 5, there were no significant differences in cardiac indications accepted by funding source, but privately-funded programs were significantly more likely than public programs to accept high-risk primary prevention patients. As shown in Table 6, in terms of HCPs on staff, publicly-funded programs had significantly more psychologists, pharmacists, and social workers, and privately-funded programs had more administrative assistants.

As shown in Table 7, privately-funded programs were significantly more likely than public programs to communicate with a patients' primary care provider and offer resistance training, however they were least likely to offer tobacco cessation interventions. Public programs were significantly more likely than private programs to offer individual consults with a nurse and psychological counselling. There were no differences observed in total elements offered by funding source.

As shown in Table 8, publicly-funded programs were of significantly longer duration than those funded by other means, resulting in significantly greater overall CR dose. Finally, as shown in Table 9, patient referral was a significantly greater barrier in privately-funded programs, while publicly-funded programs experienced significantly more human, space, and equipment barriers.

DISCUSSION

CR supply in LMICs is poor, with only ~40% of LMICs having any CR programs (with particularly low availability in LICs [only 5 programs globally, and hence results are primarily generalizable to MICs] and Africa [only 32 programs]). Where it is found, there is grossly insufficient capacity to meet the burden of disease. Available CR programs in MICs offer fewer core components; return-to-work counselling, stress management, and tobacco cessation interventions services should be offered more universally, particularly as they would be highly relevant to patients in LMICs. Programs in MICs had on average six staff, most commonly cardiologists, nurses, physiotherapists, and dietitians, offering on average 33 hours of CR to each patient over three months.

Of the 92 countries globally without CR, over 90% are LMICs. Across all LMICs, 14,766,930 more CR spots are needed annually to treat all incident IHD cases (vs only ~3.5

million needed across HICs), and even more spots would be needed to treat those with HF, among other indications. While IHD burden is still lower in LMICs than HICs, it is rapidly increasing. Clearly capacity needs to be increased. It was surprising that the programs that do exist were so comprehensive, and expensive (e.g., more use of stress tests, physicians), with a comparable staffing complement to HICs (i.e., number), as it was expected programs would be delivering the basics in an affordable manner so as to be feasible and reach as many patients as possible. This could be due to the methods of program identification in the study, or the motivation of profit given programs are more often privately-funded.

CR programs in MICs accepted guideline-recommended indications[11–13], including more recently HF[14], but more often also accepted other non-communicable diseases. Whether this brings efficiency or drains capacity for cardiac patients warrants further investigation. In HICs, CR programs more-often treat patients after advanced cardiac procedures, likely because these procedures are more often performed in these settings.

While there was a comparable number of staff on CR teams in HICs and MICs, the type of staff differed. Specifically, there was more physician contact in MICs. This could be due to lower labour costs in LMICs, or that it is cardiologists that have the capability/resources/position of opening programs in these settings. While some guidelines recommend physicians be a major part of CR team, not all do[8,9]. Task-shifting represents an important avenue to reduce the cost of CR delivery in LMICs. The International Council of Cardiovascular Prevention and Rehabilitation offers a certification program for teaching students, community healthcare workers and regulated HCPs alike how to deliver all core components in low-resource settings (http://globalcardiacrehab.com/training-opportunities/certification/).

Cost to deliver CR was significantly lower in MICs compared to HICs (consistent with most healthcare costs)[68], yet still does not appear affordable when juxtaposed against healthcare expenditure per capita in LMICs which is $455.39[69]. Patients paid part of the cost of CR in two-thirds of programs, with the median cost to patients being $338.29 USD PPP/program. Given the median annual income in LMICs is $833 USD (2013 purchasing power parity)[70], this is unaffordable. This would lead to physician failure to refer, which was the most common CR barrier in LMICs (as also reported in a recent review)[18], as well as failure of patients to initiate CR or where they do, to dropout (such that although a higher dose of CR is prescribed in LMICs, patients are likely actually receiving a much lower dose). Indeed, patient or private funding sources were significantly more common in LMICs than HICs, consistent with the fact that there is more public funding of health systems in HICs than LMICs[68]. Funding source had an impact on indications accepted (non-cardiac), dose, as well as type (but not total number) of HCPs on staff, and components offered. Publicly-funded programs do appear to be of higher quality in terms of structure. Clearly, advocacy for public reimbursement is much needed[71].

Implications

These results hold major implications for health policy. More programs are required to meet the growing need for CVD care in LMICs. The greatest barriers to CR delivery in LMICs were lack of referral (likely related to the dearth of programs to which patients can be referred), as well as lack of financial resources for both programs and patients. CR needs to be reimbursed to adequate levels to ensure delivery of all core components, by a reliable non-patient source. The cost-effectiveness of CR in LMICs has been demonstrated[33], as has been the impacts in reducing downstream healthcare utilization costs[72], and affordable CR models are established[8,73]. Given only one-fifth of programs offer alternative models (in only 22 of 136 LMICs), increasing home and community-based delivery may be an important means to increasing capacity,

particularly while exploiting information and communications technology[74]. Many LMICs already have established programs for communicable diseases, which could be re-purposed to deliver CR.

Limitations

These results should be interpreted with caution. First, some programs may not have been identified, especially in LICs where they may not have a website or published research, and in countries where no society or champion was identified. Therefore, availability, capacity, and density could be somewhat under-estimated. Moreover, due to our inclusion criteria and definition of CR (which stem from HICs), chronic disease management programs or clinics which are less comprehensive (e.g., no exercise) would not be represented. Second, though a high response rate at the country-level of 85% was achieved, response rates among programs within LMICs was just over 50%, and hence there may be some bias. However, the response rate is considered quite good for online surveys, and ultimately the sample was comprised of over half of CR programs in LMICs globally.

Third, related to measurement, information on programs was reported by staff, and while responses were confidential, respondents may have responded in a manner that reflected what they know is recommended in guidelines (i.e., socially-desirable responding). So for example, the number of elements delivered may be higher than reality. Moreover, while the survey was pilot-tested, items were not validated through verification of responses in a random sub-sample of programs. The cost items in particular should be interpreted with caution. They were not sufficiently detailed to capture what types of costs respondents included in their estimates and how they were counted, and again were not validated against actual costs.

Fourth, due to the nature of the design, causal or directional conclusions cannot be drawn. Finally, results of the study cannot be used to draw conclusions regarding whether the programs

as delivered improve patient outcomes, as that would require investigation of patient-level data. Only the structure and processes of programs were considered.

CONCLUSION

CR remains largely unavailable in the majority of LMICs. Where it exists, CR is quite consistent with guideline recommendations even from HICs, but is largely inaccessible to patients for reasons of capacity and finance. Increasing CR reimbursement, task-shifting, as well as offering more home-based programs could mitigate these barriers.

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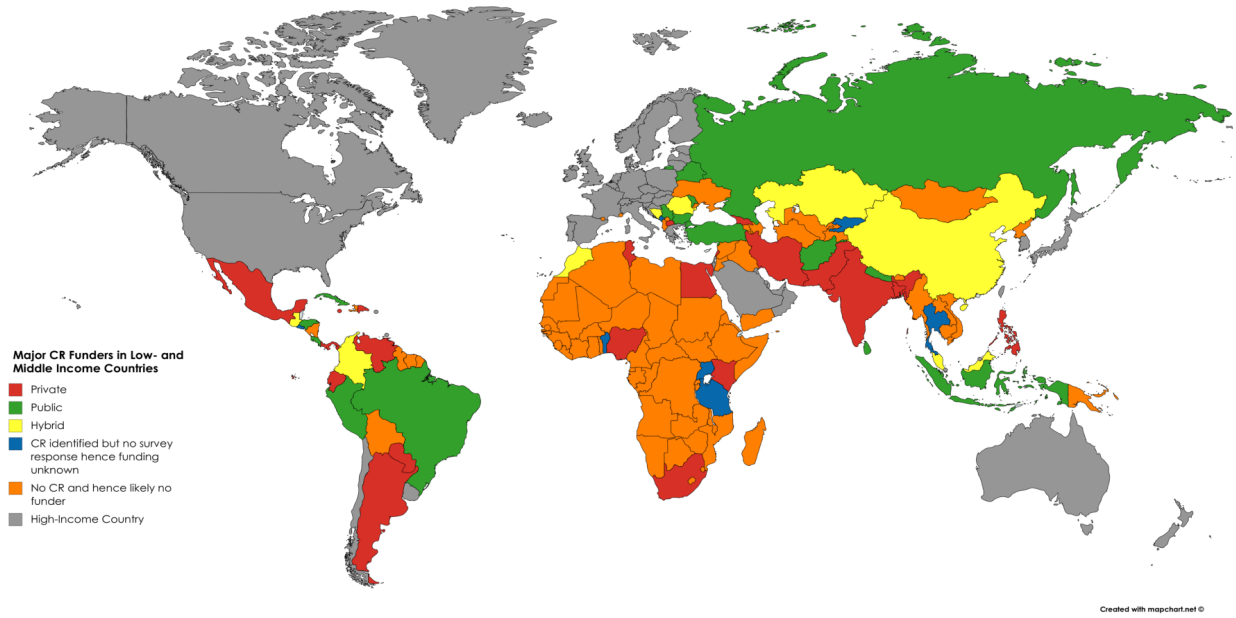
Figure 1: Most common cardiac rehabilitation funders in low- and middle-income countries*



* Based on most frequent of the 3 funding sources.
CR=cardiac rehabilitation

Figure 2: Resources required to increase alternative model delivery capacity in low- and middle-income countries

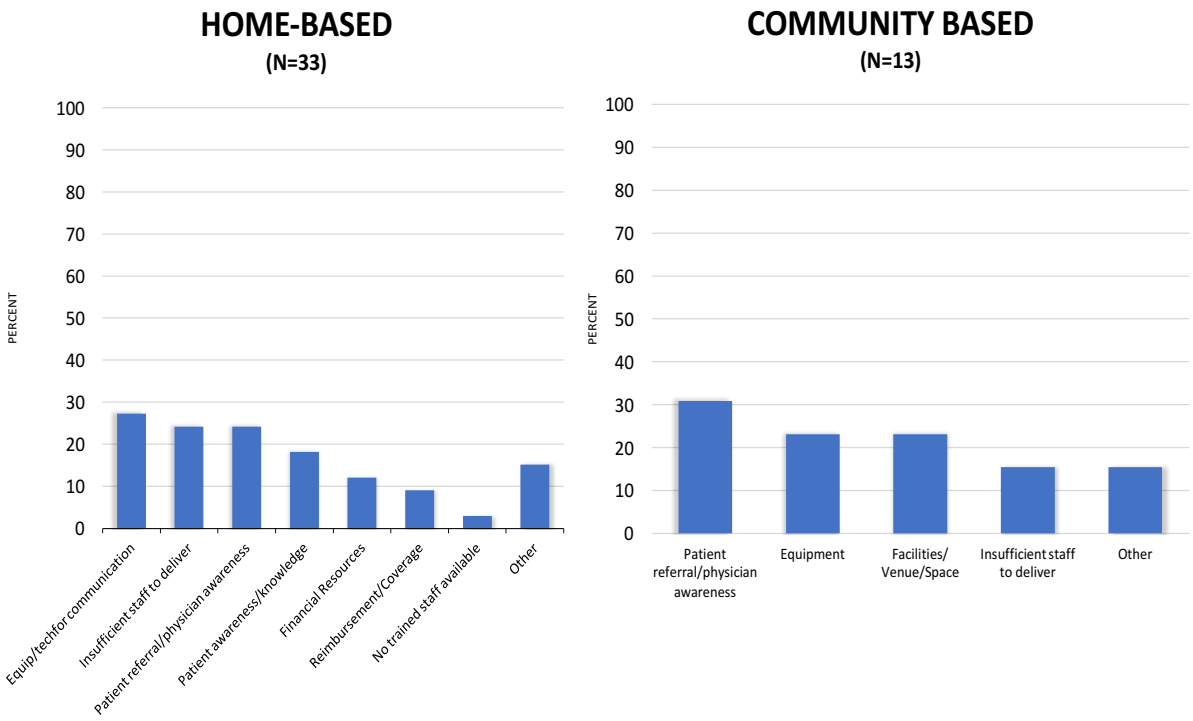


Table 1: Low- and middle-income countries suspected or known to have cardiac rehabilitation (60/138)

Country	Country Income Classification*	Region*
Afghanistan	Low-Income	South Asia
Algeria	Upper-Middle-Income	Middle East and North Africa
Argentina	Upper-Middle-Income	Latin America and the Caribbean
Belarus	Upper-Middle-Income	Europe and Central Asia
Benin	Low-Income	Sub-Saharan Africa
Bolivia	Lower-Middle-Income	Latin America and the Caribbean
Brazil	Upper-Middle-Income	Latin America and the Caribbean
Bulgaria	Upper-Middle-Income	Europe and Central Asia
Cape Verde	Lower-Middle-Income	Sub-Saharan Africa
China	Upper-Middle-Income	East Asia and Pacific
Colombia	Upper-Middle-Income	Latin America and the Caribbean
Costa Rica	Upper-Middle-Income	Latin America and the Caribbean
Cuba	Upper-Middle-Income	Latin America and the Caribbean
Dominican Republic	Upper-Middle-Income	Latin America and the Caribbean
Ecuador	Upper-Middle-Income	Latin America and the Caribbean
Egypt	Lower-Middle-Income	Middle East and North Africa
El Salvador	Lower-Middle-Income	Latin America and the Caribbean
Georgia	Upper-Middle-Income	Europe and Central Asia
Grenada	Upper-Middle-Income	Latin America and the Caribbean
Guatemala	Lower-Middle-Income	Latin America and the Caribbean

Honduras	Lower-Middle-Income	Latin America and the Caribbean
India	Lower-Middle-Income	South Asia
Indonesia	Lower-Middle-Income	East Asia and Pacific
Iran, Islamic Republic	Upper-Middle-Income	Middle East and North Africa
Iraq	Upper-Middle-Income	Middle East and North Africa
Jamaica	Upper-Middle-Income	Latin America and the Caribbean
Kazakhstan	Upper-Middle-Income	Europe and Central Asia
Kenya	Lower-Middle-Income	Sub-Saharan Africa
Korea, Democratic People's Republic	Low-Income	East Asia and Pacific
Kyrgyz Republic	Lower-Middle-Income	Europe and Central Asia
Lebanon	Upper-Middle-Income	Middle East and North Africa
Macedonia	Upper-Middle-Income	Europe and Central Asia
Malaysia	Upper-Middle-Income	East Asia and Pacific
Maldives	Upper-Middle-Income	South Asia
Mexico	Upper-Middle-Income	Latin America and the Caribbean
Moldova	Lower-Middle-Income	Europe and Central Asia
Morocco	Lower-Middle-Income	Middle East and North Africa
Nepal	Low-Income	South Asia
Nicaragua	Lower-Middle-Income	Latin America and the Caribbean
Nigeria	Lower-Middle-Income	Sub-Saharan Africa
Pakistan	Lower-Middle-Income	South Asia
Panama	Upper-Middle-Income	Latin America and the Caribbean

Paraguay	Upper-Middle-Income	Latin America and the Caribbean
Peru	Upper-Middle-Income	Latin America and the Caribbean
Philippines	Lower-Middle-Income	East Asia and Pacific
Romania	Upper-Middle-Income	Europe and Central Asia
Russian Federation	Upper-Middle-Income	Europe and Central Asia
Rwanda	Low-Income	Sub-Saharan Africa
Serbia	Upper-Middle-Income	Europe and Central Asia
South Africa	Upper-Middle-Income	Sub-Saharan Africa
Sri Lanka	Lower-Middle-Income	South Asia
Tanzania	Low-Income	Sub-Saharan Africa
Thailand	Upper-Middle-Income	East Asia and Pacific
Tunisia	Lower-Middle-Income	Middle East and North Africa
Turkey	Upper-Middle-Income	Europe and Central Asia
Uganda	Low-Income	Sub-Saharan Africa
Ukraine	Lower-Middle-Income	Europe and Central Asia
Venezuela	Upper-Middle-Income	Latin America and the Caribbean

*Based on World Bank classifications[29]

Table 2: Summary of Findings – Results from Review of National/Regional Surveys of Cardiac Rehabilitation Programs in LMICs, N=4

Region	Results								
Country (year of publication)	Number of Respondents/Centers (response rate %)	Dose§ (weeks x frequency/week)	Staff Composition	Reimbursement Source	Components Delivered	Barriers	Patients Served program or **country** (pts served/yr)	Patient diagnoses accepted	Alternate Models (% yes)
Eastern Asia and Pacific									
China (2016)[59]	10/ -	-	Physicians (100%) Nurses (85%) Dietitians (46%)	-	IA (100%) PE (100%) NC (100%)	Lack of interest (58%) Lack of human resources (58%) Lack of awareness	-	PCI (100%) HF (100%) MI (92%)	-

						(50%)			
Latin America and the Caribbean									
Latin America and the Caribbean (2009)[19]	33/ -	33 (13 x 2.5)	Cardiologists (100%) Physical therapists (94%) Dietitians (91%)	Hospital (24%) Social security (24%) Private Insurance (24%)	-	Lack of trained personnel (41%) Lack of finances (33%)	<2000 (81%)	MI (100%) PCI (97%) CABG (97%)	CB (48%)
South America (2013)[20]	107/ -	-	Cardiologists (85%) Nutritionists (72%) Physical therapists (72%)	Mixed (46%) Private Insurance (19% Patient (18%)	ET (97%) RF (96%) NC (91%)	Lack of economic resources (13%) Lack of space (6%)	180	MI (100%) PCI (99%) CABG (97%)	-
Mexico (2016)[57]	24/24 (100 %)	-	Physicians (100%) Administrative assistants (100%)	-	ET (100%) NC (90%) SM (80%)	Lack of finances (83%) Lack of trained personnel	-	IHD (100%) PCI (100%) HF (92%)	HB (37.5%)

			Physiotherapists (83%)			(67%) Deficient equipment (46%)			

§ if only a range was provided, the midpoint of ranges is reported; if multiple ranges reported, the one with the highest percentage was used
(-) Article did not report
CABG = coronary artery bypass graft; CB = community based; CR = cardiac rehabilitation; ET = Exercise training; ETS = Exercise testing; HB = home based; HF = Heart failure; IA = Initial assessment; IHD = ischemic heart disease; LMIC = low- and middle-income countries; MI = Myocardial infarction; NC = nutrition counseling; PCI = percutaneous coronary intervention; RF = Risk factor management; SM = stress management

Table 3. Availability of Cardiac Rehabilitation Programs in Low- and Middle-Income Countries, Response Rate, and Unmet Need

Income Classification Country	Number of Responses	Number of Programs	Response Rate	Unmet CR Need*
Upper Middle-Income				
Albania	0	0	-	9,490
Algeria	1	1	100.0%	-
Argentina	3	23	13.0%	76,357
Azerbaijan	0	0	-	28,593
Belarus	1	5	20.0%	87,374
Belize	0	0	-	596
Bosnia and Herzegovina	1	1	100.0%	17,068
Botswana	0	0	-	3,569
Brazil	30	75	40.0%	523,662
Bulgaria	1	1	100.0%	52,871
China	83	216	37.5%	3,034,003
Colombia	48	50	96.0%	55,745
Costa Rica	6	6	100.0%	7,568
Cuba	8	8	100.0%	48,349
Dominica	0	0	-	209
Dominican Republic	1	2	50.0%	193,919

Ecuador	2	5	40.0%	26,096
Equatorial Guinea	0	0	-	1,105
Fiji	0	0	-	1,631
Gabon	0	0	-	2,272
Georgia	13	17	76.5%	6,288
Grenada	0	1	0.0%	-
Guyana	0	0	-	1,814
Iran	14	34	41.2%	219,007
Iraq	0	0	-	117,130
Jamaica	1	3	33.3%	7,846
Kazakhstan	1	1	100.0%	57,125
Lebanon	1	1	100.0%	27,333
Libya	0	0	-	20,254
Macedonia, FYR	1	1	100.0%	8,285
Malaysia	4	6	66.7%	84,724
Maldives	0	0	-	625
Marshall Islands	0	0	-	98
Mauritius	1	1	100.0%	107,880
Mexico	9	24	37.5%	155,348
Montenegro	0	1	0.0%	2,964
Nambia	0	0	-	3,412
Nauru	0	0	-	-
Panama	1	1	100.0%	4,959

Paraguay	3	3	100.0%	14,292
Peru	7	10	70.0%	47,467
Romania	2	3	66.7%	119,335
Russia	3	-	-	1,222,142
Saint Lucia	0	0	-	288
Saint Vincent and Grenadines	0	0	-	296
Samoa	0	0	-	299
Serbia	2	2	100.0%	37,125
South Africa	14	23	60.8%	107,880
Suriname	0	0	-	1,468
Thailand	0	5	0.0%	-
Tonga	0	0	-	168
Turkey	9	10	90.0%	334,117
Turkmenistan	0	0	-	9,388
Tuvalu	0	0	-	-
Venezuela	8	9	88.9%	44,108
Program response rate in upper-MICs (30/33 countries with CR; 90.9% country response rate)	279	549	50.3%	-
Total Unmet Need in Upper-MICs	-	-	-	6,933,942
Lower Middle-Income				
Angola	0	0	-	24,579
Armenia	0	0	-	11,125

Bangladesh	1	1	100.0%	409,010
Bhutan	0	0	-	1,319
Bolivia	0	0	-	19,423
Cambodia	0	0	-	22,764
Cameroon	0	0	-	25,761
Cape Verde	0	0	-	965
Congo	0	0	-	5,921
Cote d'Ivoire	0	0	-	31,106
Djibouti	0	0	-	1,407
Egypt	2	2	100.0%	369,288
El Salvador	0	2	0.0%	-
Federated States of Micronesia	0	0	-	147
Ghana	0	0	-	36,001
Guatemala	2	2	100.0%	13,551
Honduras	1	2	50.0%	10,899
India	18	23	78.3%	3,304,474
Indonesia	10	13	76.9%	65,376
Jordan	0	0	-	22,639
Kenya	1	3	33.3%	55,114
Kiribati	0	0	-	162
Kosovo	0	0	-	-
Kyrgyzstan	0	1	0.0%	-

Laos	0	0	-	10,390
Lesotho	0	0	-	2,997
Mauritania	0	0	-	5,612
Moldova	1	1	100.0%	20,976
Mongolia	1	1	100.0%	5,241
Morocco	1	1	100.0%	156,088
Myanmar	0	0	-	108,283
Nicaragua	0	0	-	7,341
Nigeria	1	1	100.0%	223,944
Pakistan	2	4	50.0%	616,146
Palestine	0	0	-	-
Papua New Guinea	0	0	-	11,091
Philippines	10	10	100.0%	211,507
Sao Tome and Principe	0	0	-	263
Solomon Islands	0	0	-	753
Sri Lanka	2	4	50.0%	66,507
Sudan	0	0	-	111,063
Swaziland	0	0	-	1,925
Syria	0	0	-	57,355
Tajikistan	0	0	-	13,029
Timor-Leste	0	0	-	1,695
Tunisia	1	1	100.0%	50,067

Ukraine	0	0	-	519,761
Uzbekistan	0	0	-	90,959
Vanuatu	0	0	-	399
Vietnam	0	0	-	238,156
Yemen	0	0	-	69,006
Zambia	0	0	-	18,951
Program response rate in lower-MICs (15/17 countries with CR; 88.2% country response rate)	*54*	*72*	*75.0%*	-
Total Unmet Need in Lower-MICs	-	-	-	7,050,536
Low Income				
Afghanistan	1	1	100.0%	88,906
Benin	0	1	0.0%	-
Burkina Faso	0	0	-	19,241
Burundi	0	0	-	13,432
Central African Republic	0	0	-	6,831
Chad	0	0	-	16,436
Comoros	0	0	-	1,034
Democratic Republic of the Congo	0	0	-	82,818
Eritrea	0	0	-	5,386
Ethiopia	0	0	-	138,477
Gambia	0	0	-	2,607
Guinea	0	0	-	16,645

Guinea-Bissau	0	0	-	2,797
Haiti	0	0	-	23,896
Liberia	0	0	-	6,669
Madagascar	0	0	-	32,640
Malawi	0	0	-	25,374
Mali	0	0	-	17,278
Mozambique	0	0	-	41,012
Nepal	1	1	100.0%	63,134
Niger	0	0	-	23,462
North Korea	0	0	-	48,117
Rwanda	0	0	-	11,947
Senegal	0	0	-	20,843
Sierra Leone	0	0	-	9,247
Somalia	0	0	-	15,179
South Sudan	0	0	-	17,290
Tanzania	0	1	0.0%	-
Togo	0	0	-	9,988
Uganda	0	1	0.0%	-
Zimbabwe	0	0	-	21,766
Program response rate in LICs (2/5 countries with CR; 40.0% country response rate)	*2*	*5*	*40.0%*	-
Total Unmet Need in LICs	-	-	-	782,452
LMIC Program Response Rate (47/55 LMICs with CR; 85.5%	*335*	*626*	*53.5%*	-

country response rate)				
Total Unmet Need in all LMICs	-	-	-	14,766,930

LMICs, low- and middle-income countries; CR, cardiac rehabilitation
-not applicable/missing
*number of annual incident ischemic heart disease cases estimated in Global Burden of Disease study[63] minus national annual CR capacity, to reflect total number more CR spots needed per year.

Table 4: Cardiac Rehabilitation Availability, Volume, Capacity, and Density by Country with Any Cardiac Rehabilitation, N=111

Country	IHD incidence†	Year 1st CR program	# CR programs in country	Median annual volume / program	Median annual capacity / program	National CR capacity‡	CR density§	CR density ranking ‖
Low- and Middle-Income								
Afghanistan	89,056	2014	1	100	150	150	594	82
Algeria	140,592	NA	1	NA	NA	NA	NA	NA
Argentina	122,357	1998	23	1,500	2,000	46,000	3	17
Bangladesh	409,210	NA	1	160	200	200	2,046	85
Belarus	88,874	1981	5	300	300	1,500	59	68
Benin	11,973	NA	1	NA	NA	NA	NA	NA
Bosnia and Herzegovina	19,068	1959	1	800	2,000	2,000	10	35
Brazil	529,062	1973	75	60	72	5,400	98	73
Bulgaria	55,871	1958	1	2,200	3,000	3,000	19	46
China	3,104,203	1984	216	300	325	70,200	44	63
Colombia	75,245	1972	50	410	390	19,500	4	22
Costa Rica	8,288	1985	6	45	120	720	12	38
Cuba	49,789	1973	8	145	180	1,440	35	57
Dominican Republic	193,919	2016	2	NA	NA	NA	NA	NA
Ecuador	27,046	1995	5	36	190	950	29	55
Egypt	369,488	2010	2	20	100	200	1,847	84
El Salvador	9,129	NA	2	NA	NA	NA	NA	NA
FYR of Macedonia	8,285	NA	1	NA	NA	NA	NA	NA

Georgia	16,488	1994	17	180	600	10,200	2	8
Grenada	296	NA	1	NA	NA	NA	NA	NA
Guatemala	13,671	2011	2	18	60	120	114	75
Honduras	10,939	2005	2	20	20	40	274	78
India	3,313,674	1997	23	200	400	9,200	360	80
Indonesia	66,676	1985	13	98	100	1,300	51	64
Iran	235,157	1994	34	250	475	16,150	15	41
Jamaica	8,026	2006	3	24	60	180	45	62
Kazakhstan	57,125	NA	1	NA	NA	NA	NA	NA
Kenya	55,174	2010	3	20	50	150	368	81
Kyrgyz Republic	11,398	NA	1	NA	NA	NA	NA	NA
Lebanon	27,633	2014	1	100	300	300	92	71
Malaysia	86,224	2007	6	300	250	1,500	58	67
Mauritius	3,872	2013	1	60	60	60	65	70
Mexico	161,348	1944	24	38	250	6,000	27	54
Moldova	21,376	2016	1	200	400	400	53	66
Mongolia	5,241	2013	1	NA	NA	NA	NA	NA
Montenegro	3,049	NA	1	NA	NA	NA	NA	NA
Morocco	156,088	2016	1	NA	NA	NA	NA	NA
Nepal	66,134	2008	1	2,000	3,000	3,000	22	50
Nigeria	223,994	2012	1	50	50	50	4,480	86
Pakistan	622,146	2004	4	900	1,500	6,000	104	74
Panama	5,039	2006	1	38	80	80	63	69
Paraguay	14,892	2011	3	125	200	600	25	53
Peru	49,967	1992	10	80	250	2,500	20	47
Philippines	217,107	1975	10	105	560	5,600	39	61
Romania	126,835	1978	3	1,400	2,500	7,500	17	44
Russia	1,223,642	2010	3	400	500	1,500	816	83
Serbia	40,265	1968	2	1,345	1,570	3,140	13	39
South Africa	108,455	1989	23	50	90	2,070	52	65
South Korea	94,661	2009	17	200	250	4,250	22	51
Sri Lanka	66,927	2012	4	114	105	420	159	77

Tanzania	64,326	NA	1	NA	NA	NA	NA	NA
Thailand	199,828	NA	5	NA	NA	NA	NA	NA
Tunisia	50,217	2010	1	90	150	150	335	79
Turkey	337,617	2010	10	100	350	3,500	97	72
Uganda	31,951	NA	1	NA	NA	NA	NA	NA
Venezuela	45,575	1974	9	103	163	1,467	31	56
Mean ± SD	234,902 ± 610,998	1996±19	12±31	350±545	556±805	5,683±12,873	300±788	61±19
Median (IQR)	60,726 (15,291-160,033)	2005 (1982-2011)	3 (1-10)	110 (50-300)	250 (100-481)	1,500 (200-5,450)	52 (22-125)	65 (49-76)
High-Income								
Aruba	NA	NA	1	NA	NA	NA	NA	NA
Australia	80,169	1970	314	200	200	62,800	1	5
Austria	32,901	1962	26	750	200	5,200	6	31
Bahrain	3,842	1998	1	140	500	500	8	33
Barbados	1,240	1994	1	70	96	96	13	40
Belgium	66,985	1977	48	275	300	14,400	5	27
Bermuda	197	2012	1	220	400	400	1	1
Brunei	471	2004	2	55	80	160	3	19
Canada	91,030	1960	170	300	300	51,000	2	9
Chile	45,008	2009	10	30	200	2,000	23	52
Croatia	26,066	1957	3	940	940	2,820	9	34
Curaçao	NA	NA	2	120	200	400	NA	NA
Cyprus	2,665	NA	1	NA	NA	NA	NA	NA
Czech Republic	66,012	1993	15	65	200	3,000	22	49
Denmark	23,455	1990	35	200	250	8,750	3	18
England	318,284	1978	266	490	500	133,000	2	14
Estonia	10,938	1994	2	150	150	300	37	58
Finland	25,677	1978	25	55	98	2,450	11	36
France	259,251	1984	130	475	485	63,050	4	24
Germany	385,474	1950	120	800	825	99,000	4	23
Greece	61,036	1993	4	20	100	400	153	76
Guam	311	NA	1	NA	NA	NA	NA	NA
Hungary	69,698	1970	33	440	580	19,140	4	21
Iceland	1,570	1983	4	168	185	740	2	10
Ireland	16,000	1985	37	256	300	11,100	1	6

Israel	23,152	1964	22	1,000	1,000	22,000	1	4
Italy	359,226	1974	221	350	355	78,455	5	26
Japan	501,740	1990	325	150	300	97,500	5	30
Kuwait	7,648	NA	1	NA	NA	NA	NA	NA
Latvia	14,743	1997	2	150	400	800	18	45
Lithuania	23,421	1977	25	950	1,000	25,000	1	3
Luxembourg	1,683	NA	4	NA	NA	NA	NA	NA
Malta	1,958	2012	1	300	900	900	2	11
Netherlands	88,550	1974	90	555	450	40,500	2	12
New Zealand	10,110	1968	43	200	146	6,278	2	7
Northern Ireland	8,811	1980	13	255	215	2,795	3	20
Norway	15,197	NA	35	NA	NA	NA	NA	NA
Poland	237,460	1973	56	350	375	21,000	11	37
Portugal	35,884	1988	23	75	100	2,300	16	42
Puerto Rico	15,286	NA	1	NA	NA	NA	NA	NA
Qatar	7,003	2013	1	157	192	192	37	59
Saudi Arabia	82,510	NA	1	NA	NA	NA	NA	NA
Scotland	30,185	1985	69	1,025	850	58,650	1	2
Singapore	14,299	1979	7	260	438	3,066	5	28
Slovak Republic	29,436	2015	7	50	200	1,400	21	48
Slovenia	11,135	1995	2	100	150	300	37	60
Spain	175,537	1993	87	120	120	10,440	17	43
Sweden	50,475	NA	69	150	150	10,350	5	29
Switzerland	29,546	1997	51	255	255	13,005	2	13
Taiwan	43,795	1978	35	70	180	6,300	7	32
Trinidad and Tobago	4,759	NA	2	NA	NA	NA	NA	NA
United Arab Emirates	21,885	NA	1	NA	NA	NA	NA	NA

United States of America	1,344,974	1970	2,632	150	208	547,456	3	16
Uruguay	10,656	1970	12	120	200	2,400	4	25
Wales	15,432	1986	17	490	375	6,375	2	15
Mean ± SD	90,656± 206,728	1984±16	93±357	300±278	348±259	31,959±84,666	12±24	27±18
Median (IQR)	23,455 (9,461-68,341)	1984 (1973-1994)	15 (2-51)	200 (120-395)	250 (183-444)	6,278 (850-23,500)	5 (2-13)	26 (12-40)
Global Mean ± SD	***164,764 ± 464,692***	***1990 ± 18***	***52 ± 254***	***324 ± 426***	***448 ± 595***	***19,237 ± 62,588***	***153 ± 566***	***44 ± 25***
Global Median (IQR)	***40,265 (11,267-101,558)***	***1992 (1975-2009)***	***4 (1-25)***	***157 (75-350)***	***250 (150-450)***	***2,795 (420-10,440)***	***17 (4-53)***	***44 (23-66)***

†Incidence of IHD was obtained from Global Burden of Disease study[63]

‡National CR capacity calculated using median number of patients program could serve per year (from survey) multiplied by the number of programs in the country (ascertained from national champions)· Value represents the number of patients who could receive CR in a year (i.e., CR spots).

§CR density refers to the number of incident IHD cases per year per CR spot (i.e, national CR capacity).

||Ranking based on density, or ratio of need (i.e., IHD incidence) to supply (i.e., national CR capacity). Lower numbers reflect more CR spots per IHD patient (i.e., of 86 countries where CR and sufficient information are available such that 1 represents the most spots per IHD patient and 86 is the least spots per patient).

Acronyms: LIC, Low-income country; LMI, lower middle-income; UMI, Upper middle-income; HIC, high-income country; IHD, ischemic heart diseases; CR cardiac rehabilitation; NA, not available; SD, standard deviation; IQR: interquartile range; WHO, World Health Organization.

Table 5. Accepted Cardiac Rehabilitation Indications by Country Income Classification and Funding Source, N=1082

	LMIC				HIC (n=747)	p*
	Private (n=103)	Public (n=115)	Hybrid (n=108)	Total† (n=326)‖		
Cardiac						
Myocardial Infarction/ Acute Coronary Syndrome	100 (97.1%)	78 (95.1%)	90 (90.68%)	268 (96.4%)	562 (97.9%)	0.52
PCI	94 (91.3%)	78 (95.1%)	91 (97.8%)	263 (94.6%)	554 (96.9%)	0.34
CABG	98 (95.1%)	78 (95.1%)	87 (93.5%)	263 (94.6%)	551 (96.3%)	0.83
Stable coronary artery disease, without a recent event or procedure	94 (91.3%)	72 (87.8%)	87 (93.5%)	253 (91.0%)	437 (76.4%)	0.06
Heart failure	88 (85.4%)	68 (82.9%)	87 (93.5%)	243 (87.4%)	511 (89.3%)	0.25
Valve procedure	80	61	71	212	522	<0.01

	(77.7%)	(74.4%)	(76.3%)	(76.3%)	(91.3%)	
Rhythm device	75 (72.8%)	60 (73.2%)	73 (78.5%)	208 (74.8%)	454 (79.4%)	0.16
Arrhythmias	76 (73.8%)	55 (67.1%)	75 (80.6%)	206 (74.1%)	358 (62.6%)	0.49
Cardiomyopathy	75 (72.8%)	56 (68.3%)	73 (78.5%)	204 (73.4%)	437 (76.4%)	0.27
Congenital heart disease	64 (62.1%)	46 (56.1%)	66 (71.0%)	176 (63.3%)	316 (55.2%)	0.39
Rheumatic heart disease	61 (59.2%)	53 (64.6%)	62 (66.7%)	176 (63.3%)	258 (45.1%)	<0.05
Ventricular assist devices	42 (40.8%)	38 (46.3%)	54 (58.1%)	134 (48.2%)	304 (53.1%)	0.24
Heart transplant	43 (41.7%)	28 (34.1%)	36 (38.7%)	107 (38.5%)	363 (63.5%)	<0.001
Non-cardiac						
High-risk / primary prevention	87 (84.5%)ǂ	50 (61.0%)	70 (75.3%)	207 (74.5%)†	283 (49.5%)	<0.01

		ǂ				
Diabetes	85 (82.5%)	52 (63.4 %)	66 (71.0%)	203 (73.0%)	215 (37.6%)	<0.00 1
Intermittent claudication/ peripheral vascular disease	68 (66.0%)	44 (53.7 %)	59 (63.4%)	171 (61.5%)	250 (43.7%)	0.06
Chronic lung disease	66 (64.1%)	34 (41.5 %)	56 (60.2%)	156 (56.1%)	183 (32.0%)	<0.01
Stroke / transient ischemic attack	40 (38.8%)	32 (39.0 %)	31 (33.3%)	103 (37.1%)	150 (26.2%)	0.24
Cancer	35 (34.0%)	13 (15.9 %)	24 (25.8%)	72 (25.9%)	91 (15.9%)	0.18

*Generalized Linear Mixed Models were used to test for significant differences in LMICs versus HICs.

†p< 0.05 for Generalized Linear Mixed Models testing for significant differences by most common funding source;

For pairwise comparisons ǂ=p<0.01

‖respondents did not provide information on funding source for CR in 9/335 surveys

CABG=Coronary artery bypass graft; HIC=high-income country; LMIC= low- and middle-income country; PCI=percutaneous coronary intervention.

Table 6: Healthcare Professionals on Cardiac Rehabilitation Staff by Country Income Classification and Funding Source, N=1082

	LMIC				HIC (n=747)	p*
	Private (n=103)	Public (n=115)	Hybrid (n=108)	Total† (n=326)‖		
Cardiologist	91 (88.3%)	88 (92.6%)	87 (87.0%)	266 (89.3%)	453 (72.5%)	<0.001
Nurse	65 (65.0%)	79 (84.0%)	90 (90.0%)	234 (79.6%)	544 (91.7%)	<0.001
Physiotherapist	83 (81.4%)	73 (78.5%)	77 (76.2%)	233 (78.7%)	500 (79.9%)	0.60
Dietitian	82 (80.4%)	70 (75.3%)	67 (68.4%)	219 (74.7%)	520 (83.2%)	0.001
Administrative assistant / secretary	69 (68.3%)ǂ	56 (60.9%)	54 (55.1%)ǂ	179 (61.5%)†	417 (67.9%)	<0.05
Psychologist	50 (48.5%)	65 (69.9%)¶	53 (54.1%)	168 (57.1%)†	357 (58.0%)	0.69
Physiatrist / PM&R	42 (44.7%)	60 (63.2%)	51 (53.7%)	153 (53.9%)	235 (38.5%)	<0.001
Kinesiologist / Exercise specialist	61 (58.7%)	47 (50.5%)	45 (46.9%)	153 (52.2%)	310 (52.1%)	0.71
Other physician	43 (45.7%)	42 (46.7%)	32 (34.8%)	117 (42.4%)	215 (36.1%)	0.08
Sports medicine	42	23	38	103	80	<0.001

physician	(42.9%)	(25.3%)	(38.8%)	(36.1%)	(13.3%)	
Psychiatrist	33 (34.7%)	39 (42.9%)	27 (28.7%)	99 (35.4%)	107 (17.8%)	<0.001
Pharmacist	14 (14.6%)ǂǂ	41 (46.1%)ǂǂ	36 (37.9%)	91 (32.5%)††	275 (45.1%)	0.001
Social worker	16 (16.7%)ǂǂ	39 (42.4%)ǂǂ	25 (26.3%)	80 (28.3%)††	300 (48.8%)	<0.001
Community health worker	12 (12.8%)	24 (26.1%)	23 (24.5%)	59 (21.1%)	109 (18.0%)	0.28
Other	12 (21.8%)	18 (28.1%)	19 (25.7%)	49 (25.4%)	122 (39.0%)	0.001
Total # of program staff§	5.4 ± 2.5	6.3 ± 3.2	5.8 ± 2.8	5.8 ±2.8	5.9 ± 2.8	0.58

‖respondents did not provide information on funding source for CR in 9/335 surveys.
*Generalized Linear Mixed Models could not reliable be used to test for significant differences in LMICs versus HICs so Pearson's chi-square were computed.
† p< 0.05; †† p< 0.01; ††† p< 0.001 for Generalized Linear Mixed Models testing for significant differences by most common funding source;
For pairwise comparisons ǂ: one symbol=p<0.05; two symbols=p<0.01; 3 symbols=p<0.001
¶Significantly different from all funding sources (p<0.01).
HIC=high-income country; LMIC= low- and middle-income country
§frequency and percent of personnel on team, with full-time personnel counted as 1 and part-time personnel counted as 0.50.

Table 7: Cardiac Rehabilitation Elements Delivered by Country Income Classification and Funding Source, N=1082

n (%)	LMIC				HIC (n=747)	p*
	Private (n=103)	Public (n=115)	Hybrid (n=108)	Total† (n=326)ǂ		
Core Components						
Initial Assessment	105 (99.1%)	96 (100.0%)	101 (99.0%)	305 (99.0%)	634 (98.8%)	0.91
Management of CV Risk Factors	103 (97.2%)	94 (97.9%)	101 (99.0%)	298 (98.0%)	627 (98.4%)	0.75
Patient Education	87 (96.7%)	87 (91.6%)	93 (96.9%)	267 (95.0%)	591 (97.7%)	0.39
End of program re-assessment	99 (93.4%)	86 (91.5%)	87 (87.9%)	272 (91.0%)	584 (91.8%)	0.74

Prescription and/or titration of medications	88 (82.2%)	89 (92.7%)	95 (93.1%)	272 (89.2%)	476 (74.6%)	0.13
Supervised Exercise Training	92 (86.0%)	71 (75.5%)	79 (78.2%)	242 (80.1%)	530 (82.8%)	0.83
Communication of assessment results to patients' primary care provider	88 (82.2%)◊	58 (61.1%)◊	78 (77.2%)	224 (73.9%)†	562 (89.1%)	<0.01
Stress Management	73 (68.9%)	66 (70.2%)	73 (72.3%)	212 (70.4%)	556 (87.0%)	<0.01
Tobacco cessation interventions sessions/classes	50 (47.6%)¶	72 (75.0%)	67 (67.0%)	189 (62.8%)†††	500 (78.2%)	0.001
Return-to-work counselling	58 (55.8%)	62 (66.0%)	62 (62.0%)	182 (61.1%)	431 (68.2%)	<0.05
<u>Other Elements</u>						

Heart rate measurement training / exercise intensity monitoring	104 (98.1%)	93 (96.9%)	101 (99.0%)	298 (98.0%)	587 (92.3%)	0.13
Individual consult with a physician	98 (92.5%)	89 (94.7%)	95 (94.1%)	282 (93.7%)	412 (64.4%)	<0.05
Assessment of Comorbidities	95 (91.3%)	86 (90.5%)	88 (88.0%)	269 (90.0%)	605 (94.7%)	0.10
Resistance Training	102 (95.3%)◊◊	76 (80.9%)◊◊	92 (90.2%)	270 (89.1%)†	585 (91.7%)	0.17
Nutrition Counseling	91 (85.0%)	85 (88.5%)	92 (90.2%)	268 (87.9%)	609 (95.2%)	<0.05
Exercise Prescription	98 (91.6%)	83 (87.4%)	85 (84.2%)	266 (87.8%)	566 (88.6%)	0.55
Physical Activity Counseling	96 (90.6%)	82 (86.3%)	86 (86.0%)	264 (87.7%)	582 (90.7%)	0.89

Exercise Stress Test	91 (85.8%)	83 (89.2%)	76 (76.8%)	250 (83.9%)	403 (63.5%)	<0.001
Follow-up post-program	87 (82.1%)	80 (84.2%)	75 (74.3%)	242 (80.1%)	418 (65.9%)	<0.01
Depression screening	79 (74.5%)	72 (75.0%)	83 (82.2%)	234 (77.2%)	579 (90.6%)	<0.01
Other Functional Capacity Test	82 (78.8%)	72 (76.6%)	72 (72.7%)	226 (76.1%)	506 (80.4%)	0.54
Psychological Counselling	67 (63.2%)◊	76 (80.0%)◊	78 (77.2%)	221 (73.2%)†	528 (82.5%)	0.09
Electronic patient charting	58 (63.7%)	48 (58.5%)	70 (70.7%)	176 (64.7%)	294 (59.3%)	0.86
Individual consult with a nurse	42 (40.8%)◊◊◊	70 (74.5%)◊◊◊	65 (65.7%)	177 (59.8%)††	536 (84.0%)	<0.001
Assessment of strength	66 (64.7%)	49 (52.1%)	57 (56.4%)	172 (57.9%)	273 (43.5%)	0.26
Alternative forms of exercise (e.g., yoga, dance)	44 (41.9%)	46 (48.9%)	50 (51.0%)	140 (47.1%)	213 (33.7%)	0.34
Women-only classes	17 (16.2%)	19 (20.4%)	18 (18.2%)	55 (18.3%)	55 (8.7%)	0.07
Other	20 (39.2%)	22 (33.8%)	24 (36.4%)	66 (36.3%)	46 (20.1%)	0.01

Total Elements (mean ± SD / 27)§	18.2 ± 4.2	18.2 ± 4.9	18.3 ± 4.5	18.2 ± 4.5	18.9 ±3.8	0.18
Total core (/11)§	6.7 ± 2.6	6.7 ± 2.5	7.0 ± 2.4	7.3 ± 1.8	7.9 ± 1.7	<0.01

*Generalized Linear Mixed Models were used to test for significant differences in LMICs versus HICs.
† p< 0.05; †† p< 0.01; ††† p< 0.001 for Generalized Linear Mixed Models testing for significant differences by most common funding source;
‖respondents did not provide information on funding source for CR in 9/335 surveys
For pairwise comparisons ◊: one symbol=p<0.05; two symbols=p<0.01; 3 symbols=p<0.001
¶Significantly different from all funding sources (p<0.001).
CV=cardiovascular; HIC= high-income country; LMIC= low- and middle-income country; SD= standard deviation
§components offered in all models of CR counted as 1 and Components offered in some CR models counted as 0.50.

Table 8: Cardiac Rehabilitation Dose by Country Income Classification and Funding Source, N=1082

	LMIC				HIC (n=747)	p*
	Private (n=103)	Public (n=115)	Hybrid (n=108)	Total† (n=326)‖		
Duration (weeks)	10.8±6.9	14.1±13.5¶	10.8±9.6	11.7±10.2†††	10.4±9.0	0.07
Frequency (per week)	2.9±1.0	2.8±1.3	2.8±1.2	2.8±1.1	2.4±1.1	<0.001
Total Sessions / program	31.0±19.7	42.2±44.0 ¶	29.4±25.1	33.7±30.7 †††	25.9±24.9	<0.001
Minutes (per session)	56.7±19.5	54.8±24.6	57.4±20.8	56.4±21.5	60.0±17.7	<0.01
Total hours/program	29.3±20.1	43.2±52.4¶	28.7±24.7	33.2±34.5†††	26.6±25.2	<0.001

‖respondents did not provide information on funding source for CR in 9/335 surveys.
*Mann-Whitney U was used to test for significant differences in LMICs versus HICs.
† p< 0.05; †† p< 0.01; ††† p< 0.001 for Generalized Linear Mixed Models testing for significant differences by most common funding source;
For pairwise comparisons: one symbol=p<0.05; two symbols=p<0.01; 3 symbols=p<0.001
¶Significantly different from all funding sources (p<0.001).
HIC= high-income country; LMIC= low- and middle-income country

Table 9: Barriers to Cardiac Rehabilitation Delivery by Income Classification and Funding Source, N=1082

	LMIC				HIC (n=747)	p*
	Private (n=103)	Public (n=115)	Hybrid (n=108)	Total† (n=326)‖		
Patient Referral	4.2±1.3ǂǂ	3.4±1.5ǂǂ	3.7±1.4	3.8±1.4††	3.1±1.5	0.001
Financial Resources	3.4±1.5	3.5±1.5	3.6±1.4	3.5±1.5	3.5±1.4	0.91
Human Resources	2.5±1.4¶	3.4±1.4	3.0±1.4	3.0±1.5†††	3.3±1.4	0.74
Space	2.4±1.4ǂ	3.0±1.5ǂ	2.7±1.4	2.7±1.5†	2.8±1.5	0.38
Equipment	2.1±1.3ǂǂ	2.9±1.5ǂǂ	2.5±1.4	2.5±1.4††	2.4±1.3	0.14

‖respondents did not provide information on funding source for CR in 9/335 surveys.
*Generalized Linear Mixed Models were used to test for significant differences in LMICs versus HICs.
† p< 0.05; †† p< 0.01; ††† p< 0.001 for Generalized Linear Mixed Models testing for significant differences by most common funding source;
For pairwise comparisons ǂ=p<0.05; ǂǂ=p<0.01; ǂǂǂ=p<0.001
¶Significantly different from all funding sources (p<0.001).
HIC= high-income country; LMIC= low- and middle-income country

Table 10: Sources of Cardiac Rehabilitation Program Funding by Country Income Classification, N=1082

	LMIC (n=335)	**HIC** (n=747)	**p***
Patient	212 (65.0%)	184 (24.9%)	<0.001
Social Security / Government	179 (54.9%)	444 (60.2%)	0.11
Hospital / Clinical Center	61 (18.7%)	250 (33.9%)	<0.001
Private Health Insurance	105 (32.2%)	167 (22.6%)	0.001
Other	6 (1.8%)	48 (6.5%)	0.001

*chi-square tests were used to test for significant differences in LMICs versus HICs
HIC= high-income country; LMIC= low- and middle-income country

APPENDICES

Appendix A: Consent Form

International Council of Cardiovascular Prevention and Rehabilitation (ICCPR)

GLOBAL CARDIAC REHABILITATION PROGRAM SURVEY

Consent form

You are being asked to participate in a research study to understand the availability and characteristics of cardiac rehabilitation programs globally. You are being asked to participate because you are the most responsible clinician or administrator of a cardiac rehabilitation program.

What You Will Be Asked to Do in the Research:
If you agree to participate, you will be asked to respond to an online survey that takes about 20 minutes to complete.
Data will be collected primarily via online survey. Phone or paper administration may be possible in some instances if you do not have internet access and are willing to provide your information in this manner.

Confidentiality:
All information you supply during the research will be held in confidence, and your name will not appear in any report or publication of the research.

Your data will be safely stored. Each completed survey will only be identifiable by a unique research identification number. Electronic survey responses will be stored on a secure database. It will not be stored on any portable media. Only the research team will have access to the collected information. The Principal Investigators will destroy the data 15 years after the completion of the project: the electronic database will be deleted from the system. Confidentiality will be provided to the fullest extent possible by law.

Benefits of the Research and Benefits to You:
This research is designed to understand the availability of cardiac rehab, particularly in low- and middle-income countries where there is a growing burden of cardiovascular disease. We hope to use the findings to inform policy in international and national fora, on the status of and gaps in cardiac rehabilitation.

If you are interested, we will provide you with comparative information about the characteristics of other cardiac rehabilitation programs in your country or region. This information may be of use to you in advocating for CR services in your region.

You will not receive payment for your participation.

Risks and Discomforts:
We do not foresee any risks or discomfort from your participation in the research. You may refuse to answer any question(s) that you do not wish to answer.

Voluntary Participation:
Your participation in the study is voluntary and you may choose to stop participating at any time. Your decision not to volunteer will not influence the nature of the ongoing relationship you may have with the researchers, or study staff, or the nature of your relationship with York University of the Mayo Clinic either now, or in the future. You have the right to withdraw your consent or discontinue participation at any time without penalty.

Questions About the Research?
If you have questions about the research in general or about your role in the study, please feel free to contact Dr. Sherry Grace either by telephone at (416) 736-2100, extension 22364 or by e-mail (sgrace@yorku.ca) or Marta Supervia Pola by e-mail (globalcr@mayo.edu)

This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board, and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca). In addition, if you have any concerns, complaints, or general questions about research or your rights as a participant, please contact the Mayo Institutional Review Board (IRB) to speak to someone independent of the research team at 507-266-4000 or toll free at 866-273-4681.

Legal Rights and Consent:

I consent to participate in "*Global Cardiac Rehabilitation Survey: Availability and Characteristics of Programs*" conducted by Drs. Sherry Grace & Francisco Lopez. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by completing this form. My checkmark below indicates my consent.

☐ I consent

Today's date: _____ (dd/mmm/yyyy)

Appendix B: Survey

CARDIAC REHABILITATION PROGRAM QUESTIONNAIRE

1. What is your Title/Position at the cardiac rehabilitation program? (check ✓one):

   ☐ Director

   ☐ Coordinator / Manager / Supervisor

   ☐ Clinician, specify: _____

   ☐ Other, specify: _____

SECTION A: GENERAL INFORMATION

2. In what country is your cardiac rehabilitation program? _____
3. City / Region: _____(optional)
4. Your cardiac rehabilitation program is located in an:

   - Urban area (e.g.larger cities, towns)
   - Suburban (a residential district located on the outskirts of a city)
   - Rural area or countryside (a geographic area that is located outside towns and cities).

5. In what year was your cardiac rehabilitation program initiated? _____ (year)
6. Who pays for cardiac rehabilitation ? (Check all that apply)

   ☐ Social security / government

   ☐ Hospital or clinical center where the cardiac rehab service is based

☐ Patient (answer 6b & c)

☐ Private health insurance

☐ Other (specify): _____

6b. What is average percent of the total program cost that patients pay, if they complete the program?

_____ % **OR** □ I don't know

6c. What is the direct cost to patients to participate, if they complete the program?

_____ _____ **OR** □ I don't know

Amount currency

7. Is your cardiac rehabilitation program located within a hospital (check ✓one)?

☐ Yes – it is in a referral centre/ quarternary / tertiary facility and / or academic centre

☐ Yes – it is in a community hospital

☐ Yes - it is in a rehabilitation hospital/ residential facility

☐ Yes – other (please specify: _____)

☐ No **(skip to question 10)**

8. **If Q7 was marked yes**, does the hospital have an inpatient cardiology service? Check one box:

☐ Yes, and these patients are referred to our cardiac rehabilitation program regularly

☐ Yes, and these patients are sometimes referred to our cardiac rehabilitation program

☐ Yes, and these patients are rarely referred to our cardiac rehabilitation program

☐ No

9. **If Q7 and Q8 were marked** yes, do they offer? (check all that apply)

   ☐ Revascularization via percutaneous coronary intervention (PCI)

   ☐ Coronary artery bypass graft surgery (CABG)

   ☐ Percutaneous valve implantation

   ☐ Implantable heart devices (pacemakers or defibrillators)

   ☐ Cardiac transplant

   ☐ None

10. In what department is the cardiac rehabilitation program situated administratively?

   ☐ Cardiology department

   ☐ Physical Medicine and Rehabilitation department

   ☐ Internal Medicine department

   ☐ Primary / general practice

   ☐ It is in a community facility

   ☐ None – it is stand-alone

   ☐ Other (specify) :_____

11. For patients referred following a cardiac hospitalization, on average how many weeks after discharge does a patient start your program? (i.e., initial assessment appointment)

_____ weeks

12. How many unique cardiac rehabilitation patients do you <u>provide service</u> to each year in your program?

_____ patients per year

13. How many patients do you have <u>capacity</u> to serve each year, in terms of staff and space?

_____ patients per year

14. What is the cost to your program to serve one (1) patient, if they complete the program?

_____ _____ OR □ I don't know

Amount currency

15. Who can refer a patient to your program? Check all that apply

- ☐ Patients can self-refer
- ☐ Physicians
- ☐ Allied healthcare providers and / or nurses
- ☐ Community health care workers
- ☐ Other, please specify: _____

16. Are there any other Cardiac Rehabilitation programs in your area? Check one box

- ☐ Yes, within approximately a 20 km radius
- ☐ Yes, but more than 20 km away
- ☐ None
- ☐ I don't know

17. Please rate the degree to which each of the following are barriers to greater patient participation in your cardiac rehab program, from "this is definitely not an issue" to "this is a major issue": Check one per row.

	This is definitely not an issue 1	This is not an issue 2	Neutral 3	This is a minor issue 4	This is a major issue 5
Lack of patient referral	○	○	◉	○	○
Lack of equipment (specify:_____)	○	○	○	○	○
Lack of space	○	○	○	○	○

Lack of human resources	○	○	○	○	○
Lack of financial resources/ budget	○	○	○	○	○
Other (specify:_____)	○	○	○	○	○

SECTION B: DETAILS ABOUT YOUR CARDIAC REHABILITATION PROGRAM

18. Who has overall responsibility for cardiac rehabilitation at your program? Please check one box:

- ☐ Cardiologist
- ☐ Physician specialist in internal medicine
- ☐ Physical medicine and rehabilitation (physiatrist)
- ☐ Physician, other specialty (please specify: _____)
- ☐ Nurse
- ☐ Exercise physiologist
- ☐ Physiotherapist
- ☐ Other (specify)_____

19. How expensive are the following aspects of delivering your cardiac rehab program? (check one box per row)

	Free	Only a minor cost	Costs a bit	costs quite a bit	Very expensive	Not applicable as we do not have this
a. Front-line personnel						
b. Space						

c. Exercise equipment
d. Equipment / supplies for cardiovascular risk assessment (not including exercise stress tests)
e. Exercise stress testing on a treadmill or cycle ergometer
f. Patient education materials
g. Blood pressure assessment device
h. Blood collection and lipid testing
i. Free weights etc. for resistance training

20. Which of the following components of cardiac rehabilitation are provided in your program? If they are provided, are they provided in all the models you deliver? (i.e., supervised and home-based programs)?

Please check one box per row. If you only offer one model of rehabilitation and you offer the listed component, please check "yes, in all models".

	Yes In all models	**Yes For some models**	**No**
Initial assessment			
Individual consultation with a physician			
Individual consultation with a nurse			
Exercise stress test			
Other functional capacity test (please specify: _____)			
Assessment of strength (e.g., handgrip)			
Assessment for comorbidities / issues that could impact exercise (e.g., cognition, vision, musculoskeletal / mobility issues, frailty, and / or balance / falls risk)			
Exercise prescription			
Physical activity counseling			
Supervised exercise training			

Heart rate measurement training for patients

Resistance training

Management of cardiovascular risk factors

Prescription and/or titration of secondary prevention medications

Nutrition counseling

Depression screening

Psychological counseling

Smoking cessation sessions/classes

Vocational counseling / support for return-to-work

Stress management / Relaxation techniques

Alternative forms of exercise, such as yoga, dance, or tai chi (please specify: _____)

Women-only classes

End of program re-assessment

Electronic patient charting

Communication of patient assessment results with their primary care provider

Follow-up after outpatient program

Other (please specify): _____

21. How many education sessions are provided to each patient in your program? _____ (enter zero if none)

22. How many minutes on average is each education session? _____ minutes (enter zero if none)

23. In your program, do you assess the following risk factors? Please check one box per row.

	Yes	**No**
Time spent being sedentary		
Tobacco use		
Harmful use of alcohol		
Blood pressure		
Body mass Index		
Waist circumference		
Hip circumference		
Body composition		
Total Cholesterol		
Cholesterol fractions (HDL-c, LDL-c)		
Triglycerides		
HbA1c for diabetic patients		
Blood glucose for non-diabetic patients		
Sleep apnea		
Depression / Anxiety		

Physical inactivity

Poor diet

Other (please specify:_____)

24. Which types of personnel are part of your cardiovascular rehabilitation (CR) team? If they are part of your team, do they work in Cardiac Rehabilitation only, or do they have other department obligations? (Check one box in each row):

a. Cardiologist Yes- only CR ( ) Yes- partial ( )
No ( )

b. Physiatrist (Physical medicine and rehabilitation) Yes- only CR ( ) Yes- partial ( )
No ( )

c. Sports Medicine Physician Yes- only CR ( ) Yes- partial ( )
No ( )

d. Other Physician (specify:_____) Yes- only CR ( ) Yes- partial ( )
No ( )

e. Physiotherapist Yes- only CR ( ) Yes- partial ( )
No ( )

f. Nurse Yes- only CR ( ) Yes- partial ( )
No ( )

g. Nurse practitioner Yes- only CR ( ) Yes- partial ( )
No ( )

h. Psychiatrist Yes- only CR ( ) Yes- partial ( )
No ( )

i. Psychologist Yes- only CR ( ) Yes- partial ( )
No ( )

j. Social worker Yes- only CR ( ) Yes- partial ( )

No ( )

k. Dietitian Yes- only CR ( ) Yes- partial ( )

No ( )

l. Kinesiologist Yes- only CR ( ) Yes- partial ( )

No ( )

m. Pharmacist Yes- only CR ( ) Yes- partial ( )

No ( )

n. Exercise specialist Yes- only CR ( ) Yes- partial ( )

No ( )

o. Community Health worker Yes- only CR ( ) Yes- partial ( )

No ( )

p. Administrative assistant/ Secretary Yes- only CR ( ) Yes- partial ( )

No ( )

q. Other (specify): _____ Yes- only CR ( ) Yes- partial ( )

No ( )

25. Do all your clinical staff supervising patients during exercise sessions have cardiopulmonary resuscitation (CPR) training / certification?

☐ Yes

☐ No (skip to question 26)

25b. If yes, are they required to renew their CPR training regularly?

☐ Yes

☐ No

25c. If yes, is the CPR certification advanced or basic? (circle one per row)

Physicians:	Advanced	Basic
Nurses:	Advanced	Basic
Other:	Advanced	Basic

26. Does your program have each of the following ítems, and if yes, is its' use dedicated to your program or shared with another group (circle one option in each row)?

Bicycle ergometer	Dedicated	Shared	Not available
Treadmill ergometer	Dedicated	Shared	Not available
Arm cycloergomenter	Dedicated	Shared	Not available
Doppler Echocardiography	Dedicated	Shared	Not available
Stress test (no O_2)	Dedicated	Shared	Not available
Stress test with O2	Dedicated	Shared	Not available
Telemetry	Dedicated	Shared	Not available
Group education room	Dedicated	Shared	Not available
Gym space	Dedicated	Shared	Not available
Individual assessment/ Counselling room	Dedicated	Shared	Not available
Patient change room	Dedicated	Shared	Not available
Administrative office	Dedicated	Shared	Not available
Electronic patient charts	Dedicated	Shared	Not available
Resistance training equipment	Dedicated	Shared	Not available
Body composition analyzer	Dedicated	Shared	Not available
Staff meeting room	Dedicated	Shared	Not available
Staff office space	Dedicated	Shared	Not available
Other (specify):	Dedicated	Shared	Not available

27. Does your site offer a supervised Cardiac Rehabilitation program?

☐ Yes

☐ No (skip to section D)

SECTION C: CARDIAC REHABILITATION – Supervised Program

28. Which of the following cardiac diagnoses or indications do you accept for your supervised program? (Check all that apply)

- ☐ Post Myocardial Infarction / acute coronary syndrome
- ☐ Stable coronary artery disease, without a recent event or procedure
- ☐ Post percutaneous coronary intervention (PCI)
- ☐ Post coronary artery bypass graft surgery (CABG)
- ☐ Heart failure
- ☐ Patients who have had valve surgery/repair or transcatheter aortic valve implantation (TAVI)
- ☐ Heart transplant
- ☐ Patients with ventricular assist devices
- ☐ Arrhythmias (hemodynamically-stable)
- ☐ Patients with implanted devices for rhythm control (i.e., ICD / CRT, pacemaker)
- ☐ Congenital heart disease
- ☐ Cardiomyopathy
- ☐ Rheumatic heart disease
- ☐ Patients at high-risk of cardiovascular disease (primary prevention)
- ☐ Non-cardiac chronic diseases
- ☐ Other (specify): _____

29. Which of the following non-cardiac diagnoses or indications do you accept for your on-site program? (Check all that apply)

- ☐ Stroke
- ☐ Intermittent claudication / peripheral vascular disease
- ☐ Cancer
- ☐ Diabetes
- ☐ Chronic lung disease
- ☐ None
- ☐ Other (specify): _____

30. Which of the following patient levels of cardiac risk do you accept for your supervised program? (Check all that apply)

- ☐ Low
- ☐ Moderate
- ☐ High
- ☐ Not applicable because we do not risk stratify at our program

31. Do patients have an individual consult with a physician during the program?

- ☐ Yes, please specify # times in a full program: _____
- ☐ No

32. What is the standard duration of the on-site cardiac rehabilitation program that you provide to patients?

_____ weeks

33. On average, for how many sessions do patients come on-site each week?

_____ sessions per week OR _____ sessions / day (residential programs)

34. On average, how many patients are in each exercise session?

_____ patients / session

35. On average, how long is each exercise session (including warm up, aerobic exercise, strength training and/ or cold down)?

_____ minutes / session

36. What is the maximum number of patients that your program allows in the same exercise session?

_____ patients / session

37. What is the staff to patient ratio during supervised exercise at your program? _____:_____ patients

38. Which healthcare professionals are usually present during exercise sessions? (Check one box in each row)

a. Cardiologist Yes ( ) No ( )

b. Physiatrist (Physical Medicine and Rehabilitation) Yes ( ) No ( )

c. Sports Medicine Physician Yes ( ) No ( )

d. Other Physician (specify:_____) Yes ( ) No ( )

e. Physiotherapist Yes ( ) No ( )

f. Nurse Yes ( ) No ( )

g. Nurse practitioner Yes ( ) No ( )

h. Psychiatrist Yes ( ) No ( )

i. Psychologist Yes ( ) No ( )

j. Social worker Yes ( ) No ( )

k. Dietitian Yes ( ) No ( )

l. Kinesiologist Yes ( ) No ( )

m. Pharmacist Yes ( ) No ( )

n. Exercise specialist Yes ( ) No ( )

o. Community health worker Yes ( ) No ( )

p. Other (specify): _____

39. Does the supervised program offer telemetry or another method of monitoring patients' clinical status while exercising? (check all that apply)

- ☐ Yes, telemetry
- ☐ Yes, other method of monitoring; please specify:
  - ☐ Borg scale (perceived exertion)
  - ☐ Heart rate
  - ☐ Other: _____
- ☐ None

SECTION D- ALTERNATIVE MODELS OF CARDIAC REHABILITATION DELIVERY

40. Are alternative cardiac rehabilitation models such as home-based, reimbursable by government or insurance companies in your region?

- ☐ Yes; please specify which model(s):_____
- ☐ No

41. Does your cardiac rehabilitation program offer alternative models of program delivery than an on-site program?

- ☐ Yes
- ☐ No

41b. If Q41 was marked: yes, please specify (check all that apply):

- ☐ Home-based (includes web or Smartphone-based)
- ☐ Community-based
- ☐ Hybrid of supervised with home or community-based
- ☐ Other, specify: _____

If Q41b was marked: home–based program, please answer the following questions:

42. When did it start? _____ (year)

43. What proportion of your patients are served in a home-based program?

_____ %

44. Do you perceive your program has sufficient capacity to meet need/demand in the home-based model? (check on box)

- ☐ Yes
- ☐ No

44b. If NO, please specify the reason (check all that apply):

- ☐ Not enough funding
- ☐ Not enough staff
- ☐ Not enough other resources
- ☐ Patients' risk too high for unsupervised exercise
- ☐ Other. Please, specify: _____

45. What is the standard <u>duration</u> of the home-based cardiac rehabilitation program that you provide to patients?

_____ weeks

46. On average, for how many sessions (i.e., formal contact with the Cardiac Rehabilitation staff) do patients complete in the home-based program each month?

_____ sessions / month

47. On what basis are patients offered a home-based program? (check all that apply)

- Risk stratification
- Patient indication
- Distance to centre
- Time or work constraints during the Cardiac Rehabilitation centre hours
- Transportation barriers
- Patient choice
- Cost
- Other, please specify: _____

48. Does the home-based program offer telemetry or another method of monitoring patients' clinical status while exercising? (check all that apply)

- ☐ Yes, telemetry
- ☐ Yes, other method of monitoring; please specify:
  - ☐ Borg scale (perceived exertion)
  - ☐ Heart rate
  - ☐ Other: _____
- ☐ None

49. Do participants in your home-based program receive any materials to support them in the program? (check all that apply)

- ☐ Yes, they receive an activity tracker (e.g., pedometer, accelerometer, log book)
- ☐ Yes, they receive resistance training materials (e.g., therabands, dumbbells)
- ☐ Yes, they receive education materials (e.g., workbook)
- ☐ Yes, they receive other materials (please specify:_____)
- ☐ Sometimes (please specify:

  _____)
- ☐ No

50. Which of the following patient levels of cardiac risk do you accept for your home-based program? (Check all that apply)

- ☐ Low
- ☐ Moderate
- ☐ High
- ☐ Not applicable because we do not risk stratify at our program

51. What forms of communication are used with patients in your home-based program? (check one box per row, to report the frequency)

	Never	Daily	Several	Weekly	Several	Monthly	Just

	Times/week	times / month	once
Internet webpage			
email			
webcam			
Mobile phone			
Smartphone app			
Text messages			
Log or diary (paper)			
Telephone (landline)			
In-person / on-site visit			

Other (please specify:

_____)

52. Did you perceive any barriers to using these communication tools?

- ☐ No
- ☐ Yes. If yes, please specify (check all that apply):
  - ☐ Logistical problems: i.e., connection
  - ☐ Lack of patient access (i.e., patients do not have computer with email)
  - ☐ Difficulty for the clinical staff (specify:_____)
  - ☐ Difficulty for the patients (specify: _____)

☐ Other (specify):_____

53. Which providers interact directly with the patients in the home-based cardiac rehabilitation program? Please check all that apply:

- ☐ Physician, specify specialty: _____
- ☐ Nurse
- ☐ Exercise physiologist
- ☐ Physiotherapist
- ☐ Other (specify)_____

54. What do you think you would need to be ready and able to significantly increase your program's capacity to provide home-based cardiac rehabilitation services to patients?

_____

_____

_____

_____

If Q41b was marked: Community-based program, please answer the following:

55. Where does the community-based program take place?

☐ Public center

☐ Private center

☐ Semi-private center

☐ Other: _____

56. When did it start? _____ (year)

57. What proportion of your patients are served in the community-based program?

_____ %

58. On average, how many patients are in each exercise session?

_____ **patients / session**

59. How many classes do you offer in a week? _____ sessions

60. Which of the following patient levels of cardiac risk do you accept for your community-based program? (Check all that apply)

☐ Low

☐ Moderate

☐ High

☐ Not applicable because we do not risk stratify at our program

61. Which type of provider is most responsible to supervise the Community-based exercise sessions? Please check one box:

- ☐ Physician type – please specify: _____
- ☐ Nurse
- ☐ Exercise physiologist
- ☐ Physiotherapist
- ☐ Other (specify)_____

62. What is the standard duration of the community-based cardiac rehabilitation program that you provide to patients?

_____ weeks

63 On average, for how many sessions do patients complete in the community-based program each month?

_____ sessions per month

64. On what basis are patients offered a community-based program? (check all that apply)

- ☐ Risk stratification
- ☐ Patient indication
- ☐ Distance to main Cardiac Rehabilitation centre
- ☐ Time or work constraints during the Cardiac Rehabilitation centre hours

- Transportation barriers
- Patient choice
- Cost
- We do not have a main centre in a clinical setting
- Other, please specify: _____

65. Does the community-based program offer telemetry or another method of monitoring patients' clinical status while exercising? (check all that apply)

- ☐ Yes, telemetry
- ☐ Yes, other method of monitoring; please specify:
  - ☐ Borg scale (perceived exertion)
  - ☐ Heart rate
  - ☐ Other: _____
- ☐ None

66. What do you think you would need to be ready and able to significantly increase your program's capacity to provide community-based cardiac rehabilitation services to patients?

_____

_____

_____

_____

Thank you most sincerely on behalf of the International Council of Cardiovascular Prevention and Rehabilitation for the time and expertise you have committed to complete this important questionnaire.
In return for your participation, we would like to offer you some information describing the nature of cardiac rehabilitation as delivered in your country / region. This may be useful to your program.
Please note, we will not have the opportunity to compile this information and share it with you until we have finished collecting data from as many programs as possible.

If you would like to receive this information via email, please check this box

- ☐ Yes, I would like to receive information describing the nature of cardiac rehab delivered in my country / region

Please provide an email address to receive this information: _____