Funding Sources and Costs to Deliver Cardiac Rehabilitation around the Globe: Drivers and Barriers

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Funding: This project was supported by a research grant from York University's Faculty of Health.

Statement of Authorship: This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation

The authors report no relationships that could be construed as a conflict of interest.

Key words:
Cardiac rehabilitation, Global health, Health policies, Health economics, Cost

ABSTRACT

Background:

Cardiac rehabilitation (CR) reach is minimal globally, primarily due to financial factors. This study characterized CR funding sources, cost to patients to participate, cost to programs to serve patients, and the drivers of these costs.

Methods:

In this cross-sectional study, an online survey was administered to CR programs globally. Cardiac associations and local champions facilitated program identification. Costs in each country were reported using purchasing power parity (PPP). Results were compared by World Bank country income classification using generalized linear mixed models.

Results:

111/203 (54.68%) countries in the world offer CR, of which data were collected in 93 (83.78% country response rate; N=1082 surveys, 32.0% program response rate). CR was most-often publicly funded (more in high-income countries [HICs]; p<.001), but in 60.20% of countries patients paid some or all of the cost. Funding source impacted capacity (p=.004), number of patients per exercise session (p<.001), personnel (p=.037), and functional capacity testing (p=.039). The median cost to serve 1 patient was $945.91PPP globally. In low and middle-income countries (LMICs), exercise equipment and stress testing were perceived as the most expensive delivery elements, with front-line personnel costs perceived as costlier in HICs (p=.003). Modifiable factors associated with higher costs included CR team composition (p=.001), stress testing (p=.002) and telemetry monitoring in HICs (p=.01), and not offering alternative models in LMICs (p=.02).

Conclusions:

Too many patients are paying out-of-pocket for CR, and more public funding is needed. Lower-cost delivery approaches are imperative, and include walk tests, task-shifting, and intensity monitoring via perceived exertion.

INTRODUCTION

Cardiovascular diseases (CVD) are among the leading burdens of disease and disability globally[1]. In addition to health impacts, CVD also poses a major economic burden on patients, society, and healthcare systems. On a global level, it is predicted that by 2030, the total cost of CVD will rise to a staggering $1,044 billion US dollars (USD) (from $863 billion USD in 2010)[2]. Evidence suggests that CVD pushes approximately 10% of affected families into poverty in low and middle-income countries (LMICs) where the epidemic of CVD is at its worst[3].

Cardiac rehabilitation (CR) is a chronic disease management program that successfully prolongs quality and quantity of life (e.g., 25% reductions in cardiovascular mortality[4]), and hence clinical practice guidelines recommend CVD patients participate[5,6]. The cost-effectiveness of CR is well-established across many contexts and perspectives[7–10]. CR participation is associated with return to work and healthcare avoidance. CR costs much less than percutaneous coronary intervention, yet equivalent outcomes are often achieved, supporting affordability[11].

Unfortunately, CR is grossly under-used[11]. While there are multiple factors at play at the healthcare system (e.g., capacity), provider (e.g, lack of referral, lack of trained personnel to deliver CR), and patient (e.g., lack of awareness) levels[12], arguably the primary reason is financial. Most programs are under-resourced to deliver comprehensive evidence-based services. Indeed, surveys of CR programs in Australia and New Zealand[13], China[14], Japan[15], Scotland[16], Spain[17], Latin America and the Caribbean[18–20], the Arab Region as well as Canada[21] substantiate this.

CR Coverage

A major issue affecting financial viability of CR is whether services are reimbursed or "covered" by government or private insurers, among other sources. There is wide variation around the world in reimbursement sources however, and in many countries patients must pay out-of-pocket (OOP). Recently, the International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) surveyed CR leaders around the globe regarding reimbursement sources (respondents were asked to check all that apply); 61% reported the government, 55% reported patients pay OOP, and 52% reported insurance companies[22]. Clearly too many patients pay OOP for CR, and thus a better understanding of these costs is needed, given the likely impacts on utilization[23]. Indeed, the cost to patients to participate in CR has been scantly characterized[24–26].

Delivery Costs

Moreover, while financial resources are the major cause of under-utilization, little is known about the costs to deliver (quality) CR around the world. While there is variability, most patients attend supervised programs located in clinical centres[27]; on average patients exercise on site 2-3 times per week for 5 months[28]. Most programs are staffed by a multi-disciplinary team, to ensure competent delivery of all core components for secondary prevention[29]. Hence, delivering the traditional model of CR carries with it costs associated with personnel, exercise equipment and other supplies, space and other operating costs[24,25,30].

In only 14 (12.6%) of the 111 countries known to offer CR globally[31] are the costs to run a program per patient known, at a median of $884 USD (2016 PPP) in high-income countries (HICs)[32]. Where assessed, delivery costs were generally higher in private versus public healthcare systems. Moreover, CR is delivered at much lower cost in LMICs than in HICs, and what evidence is available suggests equivalent benefits are achieved[33]. Other than these, factors affecting delivery costs have never been examined to our knowledge.

Therefore, the objectives of this study were to characterize: (1) funding source, and (1b) the proportion of the program cost as well as (1c) direct cost, to patients where they pay for CR; and (2) the estimated cost to CR programs to provide service to 1 patient, (2b) which aspects of program delivery are perceived as most expensive, and (2c) whether cost varies by funding source in countries around the globe that deliver CR. The association of: (3i) a program's patient capacity per year, (ii) the number and nature of healthcare professionals on the CR team, (iii) the number of patients served per exercise session (including staff-to-patient ratio), (iv) the number and nature of core components the program delivers; (v) the dose of CR (i.e., duration of program in weeks x the frequency of sessions per week); (vi) the equipment/resources the program has (e.g., exercise equipment, supplies for cardiovascular risk assessment) including whether patients are monitored during exercise using telemetry, and (vii) whether the program offers alternative CR models (i.e., home or community-based) to both funding source (1) and cost to treat 1 patient (2) will also be explored, to understand factors that impact CR delivery costs. Finally, (4) the degree to which financial and other resources serve as barriers to CR delivery will be described. Each will be compared by country income classification (i.e., HICs vs LMICs), and described in all countries of the world where CR is offered.

METHODS

Design & Procedure

This research was observational and cross-sectional in design; detailed methods are reported elsewhere[31]. In brief, countries where CR services were available were identified first through previous reviews[11,23]. In countries where CR services were not suspected to be available, the internet was searched and major CR and cardiology societies were contacted to identify any programs or verify lack thereof.

For each country identified to offer CR, first available CR or cardiac societies leadership was contacted, and if there was no society available or response, “champions” were identified. Identified leaders were sent an e-mail requesting their collaboration to administer the survey to each program in their country.

The most responsible clinician at each program was emailed with the request to complete the survey. Informed consent was secured through an online form. The survey was administered through REDCap, with data collection occurring from June 2016 to July 2017. Contacts were sent 2 e-mail reminders, at 2 week intervals.

Sample

The sample consisted of all CR programs identified in the world, that offer services to patients following an acute cardiac event or hospitalization (i.e., Phase II). This includes residential programs[34]. The inclusion criteria were CR programs that offered: (1) initial assessment, (2) structured exercise, and (3) at least one other strategy to control CV risk factors.

Measures

Development of the survey is described in detail elsewhere[21]. In short, items were based on previous national/regional CR programs surveys (e.g.,[19,27,35]). Most items had forced-choice response options, and skip-logic was used to obtain more detail where applicable. The survey is available elsewhere[31].

Respondents were asked to state their country. These were also categorized as high vs LMIC based on the World Bank classifications (http://data.worldbank.org/country).

Cost-related items used herein included: who pays for CR (i.e., public sources such as government, private sources such as insurance companies or patients [and the amount they pay], or other sources), the cost to the CR program to serve one patient if they complete the program , perceived expense of various CR program elements, and resource-related barriers to CR delivery (the latter 2 were rated on a 5-point Likert-type scale). The drivers of costs were also assessed, including: annual patient capacity, types of personnel on the CR team, staff-to-patient ratio during exercise sessions, and telemetry monitoring of patients, core components delivered, dose and alternative model delivery (i.e., home and community-based).

Costs were reported using purchasing power parity (PPP), which is a widely used metric to standardize and compare countries' currencies (i.e., equilibrium using a "basket of goods" approach). PPPs (2016 $USD) for CR costs in each country were computed using a cost conversion tool developed by the Cochrane Economic group (http://eppi.ioe.ac.uk/costconversion/default.aspx).

Data analysis

SPSS version 24 was used for analysis[36]. All initiated surveys were included. The number of responses for each question varied due to missing data (e.g., respondent did not answer a question due to lack of willingness or potential inapplicability, use of skip logic); for descriptive analyses, percentages were computed with the denominator being the number of responses for a specific item.

Descriptive statistics were applied for all closed-ended items in the survey (i.e., objective 1). All open-ended responses were coded / categorized. Associations were first tested on a univariate basis, using chi-square, t-tests, analysis of variance or correlations as appropriate.

Costs and funding sources were then compared by World Bank country income classification, using generalized linear mixed models to take into consideration the multi-level nature of the data, to handle missing data and different distributions of the dependent variables. Given variation in healthcare systems around the globe, country-level comparisons were not undertaken inferentially.

RESULTS

As reported elsewhere,[31] there were 111/203 (54.68%) countries in the world with CR, of which data were collected in 93 (83.78%). The number of responses (mean=9.74±17.26/ country), and response rate (32.07% overall) by country are also reported there. The total sample size was N=1082 surveys.

Cardiac Rehabilitation Funding Sources

CR funding source is shown by country in Figure 1. Overall, in 46 (49.46%) countries CR was most often paid by public sources (i.e., government, hospital), in 22 (23.66%) countries CR was paid by private sources (i.e., patients [n=22, 100.00%] or private healthcare insurance [n=12, 54.54%]), and in 25 (26.88%) countries CR was paid by a combination of these sources. Some respondents also listed other sources, which included research (n=8 programs), fundraising/charity foundations (n=4), and veteran services (n=3).

CR was significantly more often paid by public (n=489, 66.40%) sources in HICs than in LMICs (n=103, 31.70%, p<0.001). Accordingly, CR was less often paid by private (n=87, 11.80%) and hybrid (n=161, 21.80%) sources in HICs than in LMICs (n=115, 35.30%; p<0.001; and n=107, 33.10%; p<0.001 respectively).

For the countries where patients paid some or all of the program cost (n=56, 60.20%), the mean proportion of the program cost and the amount they paid are shown in Table 1. Patients in

Kenya and the Philippines paid all of the cost in most programs; patients pay all the cost in some programs in Greece, Pakistan, Peru and New Zealand. The cost to the patient was the highest in the following countries (PPP2016): Greece, Spain and Mexico (as well as Tunisia, but with only 1 response caution is warranted). The proportion of the program that patients paid (p=0.19) nor the direct cost to patients (where they pay) for CR (p=0.79) were not significantly different in HICs than in LMICs.

Table 2 shows aspects of CR programs that are associated with funding source. As shown, program capacity (greater with hybrid sources), healthcare providers on team (greater with public than private funding), individual consult with physicians (greater with private funding), cardiopulmonary stress testing (greater with private funding), and patients per exercise session (greater with public and hybrid than private funding) varied significantly by funding source. When testing each of the 10 core components individually, tobacco cessation (p<0.001), return-to-work counselling (p=0.02), and patient education (p<.01) were significantly more-commonly offered with public funding. While funding source was not associated with delivery of CR in any alternative setting, programs with public funding more often offered community-based CR specifically than privately-funded ones (p=.03). No other associations were observed. Finally, Table 2 also shows that program capacity (higher where patients paid), the number of healthcare providers on the CR team (lower), and number of core components delivered (lower where patients paid) were also significantly different based on whether patients paid for at least some of program costs or not.

Costs to Deliver CR

The estimated cost to deliver a full CR program to one patient is shown in Table 1. This did not differ significantly in LMICs versus HICs. Costs were highest in the following HICs:

Bermuda, Austria, United States; costs were lowest in Chile, Uruguay and Singapore. Costs were highest in the following LMICs: Macedonia, Dominican Republic, and Venezuela; costs were lowest in Cuba, Pakistan and Indonesia.

The elements of CR that contribute to these costs are shown in Supplementary Table 1. As shown, in HICs, front-line personnel and exercise stress testing were perceived as most expensive and in LMICs, exercise equipment and exercise stress testing were perceived as most expensive. Front-line personnel was considered significantly more expensive in HICs than LMICs ($p<0.01$); no other differences were observed.

Drivers of costs in HICs and LMICs are shown in Table 3. In HICs, program delivery costs significantly varied by funding source (i.e., higher with public and hybrid than private, and no patient finding versus any), were significantly higher with greater program capacity (and volume; data not shown), more providers on the healthcare team, higher where there was a physician on the CR team and patients had an individual consult with said physician, patients undergo cardiopulmonary stress tests, more core components are delivered, and patients are monitored with telemetry during exercise. In LMICs, higher program delivery costs were similarly associated with greater program capacity and with a greater number of providers on the healthcare team (trend for physicians specifically), but also with fewer patients per exercise session, and were significantly lower where programs offered alternative CR models (e.g., unsupervised). There was only a trend for funding source.

Degree to Which Financial Resources Are Barriers to Cardiac Rehabilitation Delivery

Finally, the perceived degree to which financial factors impede greater CR provision is reported by country[37] and by country income classification elsewhere[38]. When compared by funding sources, human resources, space and equipment were greater delivery constraints with public funding compared to private funding (Supplementary Figure 1).

DISCUSSION

CR funding and costs have been characterized globally for the first time herein. Of the countries with CR in the world (just over half), CR was funded from public sources solely in half, and this was more common in HICs (consistent with the fact that there is more public funding of health systems in HICs than LMICs[39]). Funding source impacted delivery costs, program capacity, patients per session, number and nature of healthcare providers on the team, and types of functional testing used. Moreover, some key CR components that would likely result in greater return-on-investment and downstream cost-savings (e.g., return-to-work and tobacco cessation counselling) were significantly more-commonly offered with public funding. CR resource availability, investment and care quality should not be impacted by funding source.

In almost 2/3rds of the countries with CR, patients are paying for some or all of their CR programs OOP (on average 50% of the program cost or over 600PPP/$USD2016). This would lead to greater under-utilization. Given more patients in LMICs pay OOP than HICs, yet there is no significant difference in the proportion of the program costs paid or the amount in LMICs vs HICs (which likely reflects the fact that healthcare is more expensive in HICs[39]), this represents an especially heavy burden on patients in LMICs where economic well-being is significantly lower.

The estimated cost to deliver CR to 1 patient, which should indeed be considered a gross estimate at this stage, was consistent in high LMICs (~$1500 2016PPP). Whether this represents a sufficient investment for effective CR remains to be established. These costs varied in relation to CR personnel composition, including physicians who are generally more expensive.

Cardiopulmonary stress testing and telemetry monitoring increased costs in HICs and alternative models reduced them in LMICs. The main costs associated with CR delivery were for exercise equipment, human resources and exercise stress testing, with most of these factors impeding CR delivery to a much greater degree in programs with some public funding. In LMICs, higher volume of patients per exercise session was associated with cost efficiencies.

The $1500PPP cost to deliver CR is considerably lower than percutaneous intervention[40,41], which is sometimes performed without benefit when compared to optimal medical therapy. Moreover CR results in less healthcare utilization and more return-to-work, which further economically benefits society, adding further value to the low delivery cost. The only other available data on overall program costs[32] stem from the HICs of Canada ($884 2016USDPPP)[25] and Australia ($1312 2016USDPPP)[24]. In the former, while human resource and equipment costs were high, space figured more prominently, as it did in the Australian study (although they considered some unit costs not assessed herein such as "administration" and "technology" which should be considered in future research). The available literature on CR personnel costs specifically is reviewed elsewhere[32]. Given the multi-component nature of CR, and hence the multiple disciplines required to deliver it comprehensively, personnel costs are understandably quite high. There is wide variation in the staffing complement of CR programs (as well as country norms[31]; e.g., more nurse-led programs in Australia vs more physician-led programs in the United States), as well as program policies around staff-to-patient ratios during exercise for safety[21,42,43]; correspondingly overall costs to programs would vary. In LMICs, exercise equipment is considered the most expensive aspect of program delivery. As per the International Council of Cardiovascular Prevention and Rehabilitation (ICCPR) consensus statement on CR delivery in low-resource setting, low-cost alternatives for exercise equipment are put forward[44,45], which should be seriously considered based on these findings.

In many LMICs (55.32% of those with CR), the cost of CR delivery is higher than the mean health expenditure per capita (although we concede this is a crude comparison, but it does reflect affordability and relative investment). This would be an even higher percentage if we considered revascularization, yet we would not argue it should not be delivered, and therefore we need to consider how CR can be delivered in a safe, high-quality manner while containing costs. In addition to the suggestions to keep costs down in ICCPR's consensus statement[44,45] and our previous review[32], based on the findings herein, strategies to reduce costs that should be tested include task-shifting to less expensive personnel (e.g., community healthcare workers), using physicians for consultation purposes as needed only, using a cheaper functional test than a cardiopulmonary stress test such as a 6 minute walk or shuttle walk test[46], exercising more patients per session, delivering exercise through non-equipment-based modalities, and not monitoring patients with telemetry during exercise unless they are established as high-risk. But more research needed as we do not know how these factors may impact program quality or safety.

Limitations

Caution is necessary when interpreting the findings, particularly due to limits on generalizability. Firstly, response rates to online surveys are notoriously low. While generalizability to countries with CR can be considered high, extrapolation within some countries should be undertaken with caution due to low program response rates. Second, it may not have been possible to identify programs, especially in LMICs where they may not have a website or have published any research, and in countries where no society or champion was identified. Therefore, extra caution should be taken when generalizing results from these countries.

The final limitation relates to measurement. Costs were self-reported and in most cases likely estimated, such that there is likely much measurement error. Moreover, there are no international accounting standards for program-level costing. Therefore, it was not considered appropriate to compare costs across countries (moreover given the variation in disease burden and severity, the likely variation in CR dropout rates, etc. by country). The cost items in the survey were not sufficiently detailed to capture what types of costs respondents included in their estimates (e.g., capital, overhead, how human resource costs are partitioned on a per patient basis). Additionally, costs were likely considered differently depending on the health system in a given country (e.g., budgeted values, charges or billing data, or actual total or marginal costs). However the $1500PPP cost is consistent with delivery costs in Canada and the United Kingdom for example, and hence the data appear reasonable. Future research is needed to better characterize unit costs of CR delivery globally. On a related note, mean healthcare expenditure values used to put the costs in context were not available post-2014, yet data were collected in 2016.

Conclusion

Where available, CR is most often funded by public sources, but in 60% of programs, patients pay all or part of the cost OOP (on average half of the program cost or over $600PPP). The $1500 cost to treat one patient was driven primarily by personnel, exercise equipment and exercise stress testing costs, and varied by funding source in HICs. Funding source was also related to program capacity, patients per session, number of personnel (including physicians), and the type of functional capacity test used. Public (including hybrid) funding for CR had distinct advantages. Task-shifting, use of functional walk tests, exercising more patients per session, not monitoring with telemetry and offering CR in alternate/unsupervised settings can reduce costs; safety of such approaches warrant testing on a large-scale.

Declarations:

Author's contributions MM computed PPPs, undertook the analysis and drafted the manuscript. EP supported data collection and undertook data cleaning, provided results summaries to participating countries and respondents who requested it, and collaborated on analyses. MS revised the survey, generated the online survey in REDCap, and collected data. KTA contributed to study design including measures, data acquisition (i.e., identifying countries with cardiac rehabilitation and contacting champions to collect data from programs), and verification. FLJ substantially contributed to conception and design of work and facilitated data collection in the United States and South America. ES provided health economic expertise. SLG conceived and designed the study, provided overall direction for the study, and interpreted data for this paper. All authors revised the draft critically for important intellectual content and approved the final manuscript.

Acknowledgments: On behalf of the International Council of Cardiovascular Prevention and Rehabilitation through which this study was undertaken, the Global CR Program Survey Investigators are grateful to all other national champions who collaborated to identify and reach programs in their country or region, namely: Dr. Karl Andersen, Dr. Graciela Gonzalez, Jong Seng Khiong, Dr. Tee Joo Yeo, Dr. Lucky Cuenza, Dr. Jacqueline Cliff, Dr. Claudia Anchique-Santos, Dr. Evangelia Kouidi, Dr. Eduardo Rivas Estany, Dr. Chul Kim, Dr. Rosalia Fernandez, Dr. Basuni Radi, Dr. Dan Gaita, Dr. Abraham Babu, Dr. Attila Simon, Dr. Ssu-Yuan Chen, Dr. Juan Castillo Martin, Dr. Lela Maskhulia, Dr. Wayne Derman and Dr. Gerard Burdiat, We gratefully acknowledge the World Heart Federation who formally endorsed the study protocol, as well as the International Society of Physical and Rehabilitation Medicine for their collaboration in national champion and program identification. Finally, we thank the Institute for Social Research at York University for their help with our statistical analyses.

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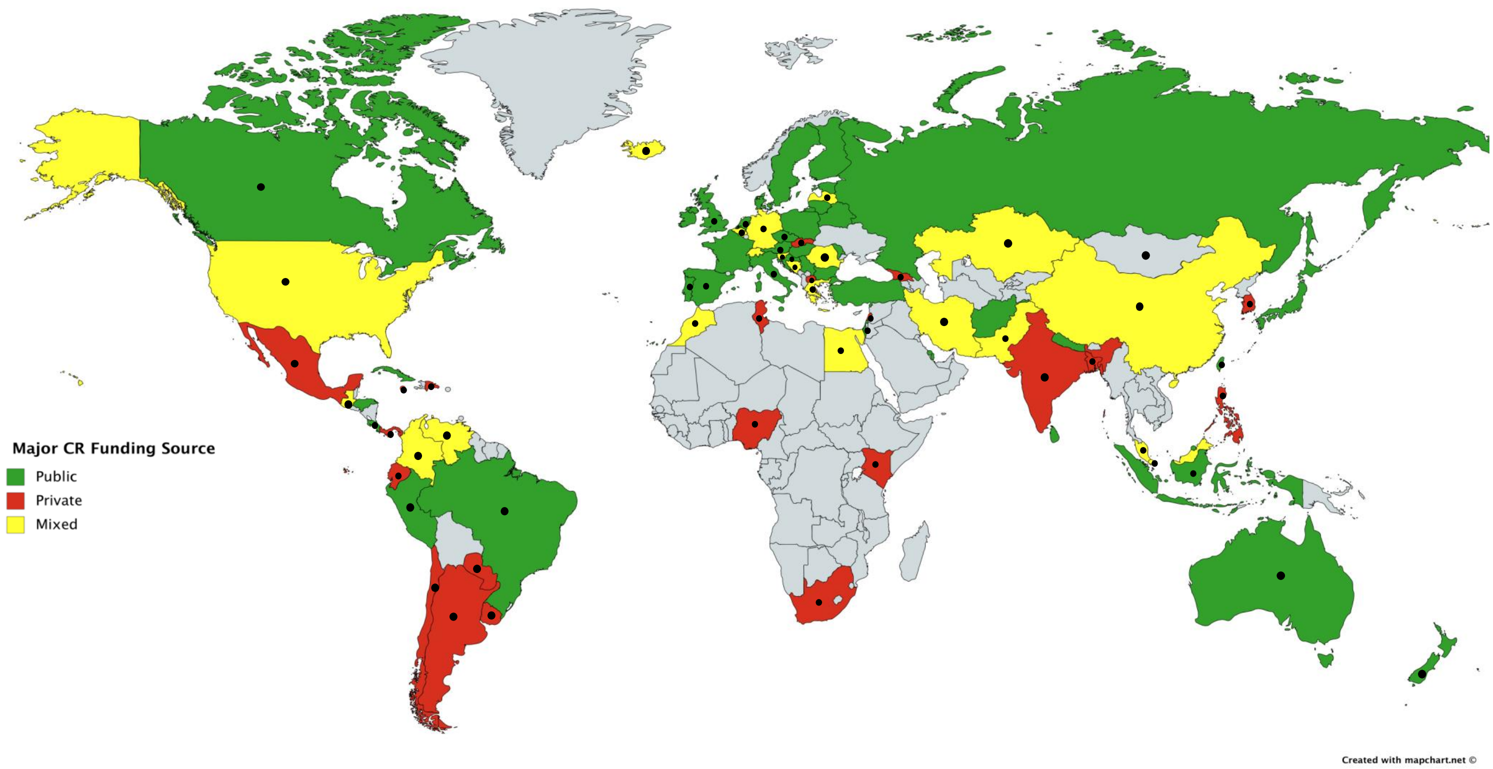
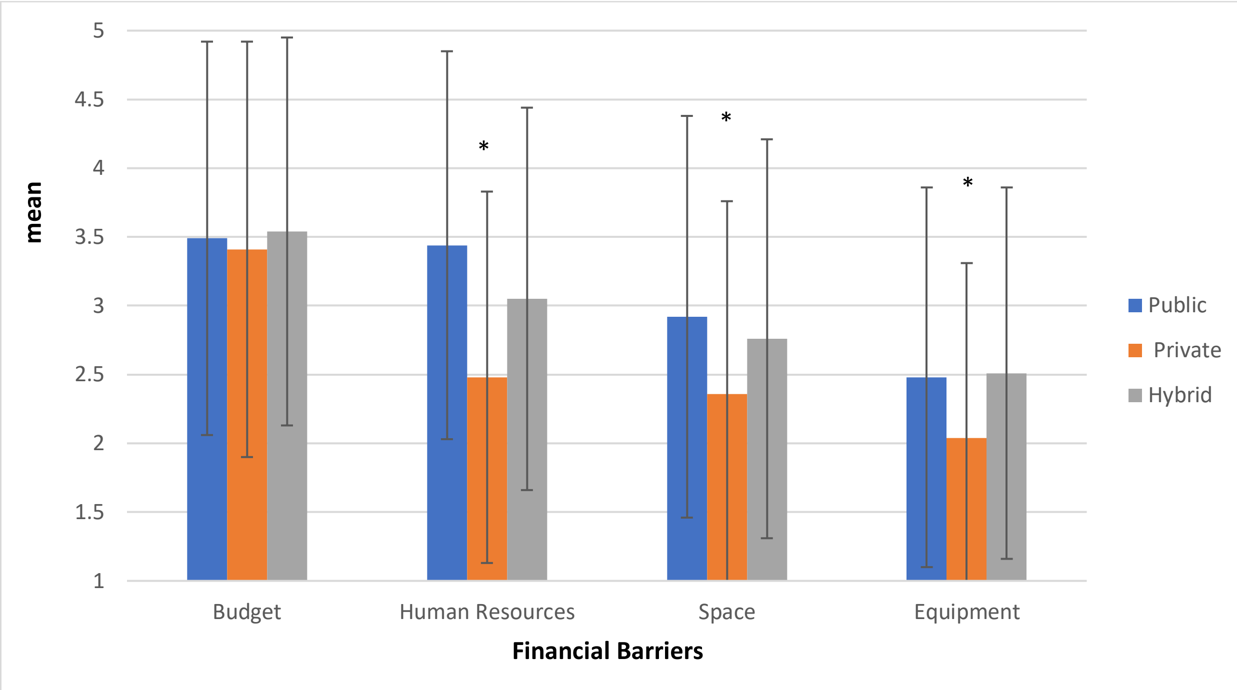
Figure 1 –Most Common Cardiac Rehabilitation Funding Source by Country, Including Patients.



- Patients pay some or all of costs
- Country has no CR

CR, Cardiac Rehabilitation

Supplementary Figure 1. Degree to which financial resources serve as barriers to cardiac rehabilitation delivery by funding source†



*p<.001.
Rating scale from 1="not an issue" to 5 "major issue".
†shown by country income classification elsewhere[38].

Table 1: Patients Paying for CR, as well as Cost to Deliver CR Juxtaposed by Mean Healthcare Expenditure Per Capita, by Country with CR and Country Income Classification, N=1082

Income Classification Country	n	Proportion of Program Cost Patient Pays (Mean ± SD %)	Direct Cost to Patient (2016 PPP†) Mean ± SD	Cost to Deliver CR to 1 Patient (2016 PPP†)§ Mean ± SD	Healthcare Expenditure per Capita in 2014 PPP[47] (CR proportion)
High-Income					
Australia	85	37.33 ± 54.42	$144.88 ± $280.41	$1023.99 ± $602.76	$6031.11 (16.98%)
Austria	5	_	_	$5668.26 ± $421.90	$5580.49 (101.57%)
Bahrain	1	0	NA	_	$1242.84
Barbados	1	0	NA	_	$1146.04
Belgium	9	9.70 ± 6.83	$317.77 ± $231.50	$1951.81 ± $945.05	$4839.83 (40.33%)
Bermuda	1	_	_	$7,073.00	n/a
Canada	55	33.23 ± 38.66	$275.29 ± $194.68	$938.29 ± $563.81	$5291.74 (18.58%)
Chile	1	50.00	$100.00	$100.00	$1137.35 (8.79%)
Croatia	3	17.00 ± 0.00	$73.44 ± 0.00	$346.40 ± $158.28	$1050.33 (32.98%)

Czech Republic	6	50.00 ± 0.00	$185.82	$3493.38	$1378.52 (253.42%)
Curaçao	1	_	_	$586.00	_
Denmark	1	0	NA	$1960.53	$6463.24 (30.33%)
Estonia	2	0	NA	$938.63 ± $0.00	$1248.28 (75.19%)
Finland	11	0	NA	$984.66 ± $894.82	$4612.29 (21.34%)
France	16	0	NA	$4598.05 ± $2066.49	$4958.99 (92.72%)
Germany	34	12.82 ± 25.97	$734.14 ± $700.61	$2427.81 ± $977.11	$5410.63 (44.87%)
Greece	4	100.00 ± 0.00	$3114.75 ± $231.84	$1967.21 ± $1614.57	$1743.04 (112.85%)
Hungary	20	0	NA	$1467.41 ± $183.66	$1036.62 (141.56%)
Iceland	4	56.00 ± 26.51	$309.45 ± $152.01	$2369.77 ± $3754.25	$4661.62 (50.84%)
Ireland	6	0	NA	$716.33 ± $0.00	$4239.15 (16.90%)
Israel	6	15.00 ± 21.21	100.00	$1450.00 ± $1100.00	$2919.29 (49.67%)
Italy	68	47.20 ± 39.64	$1675.00 ± $2238.71	$4375.73 ± $2111.61	$3257.75 (134.32%)
Japan	9	0	NA	$396.00 ± $434.46	$3702.95 (10.69%)
Latvia	1	13.00	$262.10	$2096.77	$920.70 (227.74%)
Lithuania	9	0	NA	$1400.29 ± $467.15	$1063.42 (131.68%)

Netherlands	29	15.00	_	$1662.51 ± $1297.79	$5693.86 (29.20%)
New Zealand	27	100.00 ± 0.00	$491.19 ± $129.35	$557.81 ± $740.05	$4896.35 (11.39%)
Northern Ireland	10	0	NA	$859.60	n/a
Poland	20	0	NA	$1507.98 ± $810.68	$910.28 (165.66%)
Portugal	20	53.20 ± 44.17	$694.99 ± $1277.56	$789.93 ± $610.14	$2096.82 (37.67%)
Qatar	1	0	NA	_	$2106.35
Russian Federation	3	0	NA	_	$892.85
Scotland	23	60.00	_	$778.65 ± $502.25	$3934.82 (19.79%)
Singapore	7	45.00 ± 37.75	$263.87 ± $247.23	$226.37 ± $93.86	$2752.32 (8.22%)
Slovak Republic	1	95.00	$374.22	$374.22	$1454.81 (25.72%)
Slovenia	2	75.00	$383.97	$1277.13 ± $1263.11	$2160.75 (59.11%)
South Korea	12	98.18 ± 6.03	$681.03 ± $445.72	$820.20 ± $429.63	$2060.25 (39.81%)
Spain	47	_	$2470.06 ± $740.98	1679.14 ± $1466.69	$2658.27 (63.17%)
Sweden	1	0	NA	_	$6807.72
Switzerland	4	_	_	$1601.83 ± $1189.05	$9673.52 (16.56%)
Taiwan	22	9.83 ± 1.36	$151.53 ± $45.11	$894.14 ± $775.41	n/a

United Kingdom	57	66.5 ± 47.37	$157.59	$731.54 ± $220.07	$3934.82 (18.59%)
United States	65	15.78 ± 8.45	$1272.00 ± $2291.59	$5016.60 ± $2723.11	$9402.54 (53.35%)
Uruguay	5	75.00 ± 28.87	$722.56 ± $1035.39	$148.16 ± $97.73	$1442.27 (10.27%)
Wales	15	_	$35.82	$1002.87	_
HIC Mean ± SD		*40.67 ± 38.87*	*$675.49 ± $1178.54*	*$1865.48 ± $1857.57*	*$3420.37 ± $2315.79*
HIC Median (Q25-Q75)		*20.00 (10.00-86.25)*	*$244.86 (142.40-595.66)*	*$1267.10 (580.63-2427.04)*	*$2835.81 (1345.96-4912.01)*
Low and Middle-Income					
Afghanistan	1	0	NA	_	$56.57
Algeria	1	_	_	_	$361.73
Argentina	3	75.00 ± 35.35	$47.50 ± $10.61	$1200.00	$605.19 (198.28%)
Bangladesh	1	20.00	$336.38	$336.38	$30.83 (1091.08%)
Belarus	1	0	NA	_	$450.21
Bosnia and Herzegovina	1	20.00	$175.95	$879.77	$463.64 (189.75%)
Brazil	29	77.5 ± 36.15	$1262.22 ± $453.69	$844.57	$947.43 (89.14%)

Brunei Darussalam	2	0	NA	_	$957.60
Bulgaria	1	0	NA	_	$661.85
China	81	40.82 ± 30.00	$618.37 ± $672.60	$706.75 ± $734.16	$419.73 (168.38%)
Colombia	47	14.33 ± 7.68	$132.92 ± $141.53	$833.96 ± $597.59	$569.18 (146.52%)
Costa Rica	6	_	$867.38 ± $802.39	$300.00	$970.00 (30.93%)
Cuba	8	0	NA	$45.28	$816.62 (5.54%)
Dominican Republic	1	15.00	_	$3549.61	$268.99 (1319.60%)
Ecuador	2	_	$450.00	$900.00 ± $848.53	$579.19 (155.39%)
Egypt	2	20.00	$150.00	_	$177.77
Georgia	11	83.75 ± 29.61	$749.86 ± $540.81	$729.53 ± $284.76	$302.60 (241.09%)
Guatemala	2	10.00	$89.57	_	$232.62
Honduras	1	_	_	$300.00	$212.31 (141.30%)
India	18	90.78 ± 23.87	$357.61 ± $195.55	$1027.12 ± $2030.27	$74.99 (1369.68%)
Indonesia	9	21.67 ± 25.66	$541.20 ± $327.06	$276.05 ± $14.21	$99.41 (277.69%)
Iran	14	29.82 ± 18.08	$249.16 ± $343.18	$1906.88 ± $2947.68	$350.74 (543.67%)
Jamaica	1	_	_	_	$266.19

Kazakhstan	1	_	_	_	$538.78
Kenya	1	100.00	$1598.30	$1598.30	$77.69 (2057.28%)
Lebanon	1	80.00	$1000.00	$1000.00	$568.71 (175.84%)
Macedonia	1	_	_	$6116.21	$353.92 (1728.13%)
Malaysia	4	25.00 ± 22.91	$255.63 ± $72.30	$749.83 ± $379.53	$455.82 (164.50%)
Malta	1	0	NA	_	$2470.59
Mauritius	1	_	_	_	$482.45
Mexico	9	84.17 ± 29.39	$2400.41 ± $1919.58	$1808.92 ± $1955.39	$677.19 (267.12%)
Moldova	1	0	NA	$944.80	$228.85 (412.85%)
Morocco	1	_	_	_	$190.05
Mongolia	1	_	_	_	$195.33
Nepal	1	0	NA	_	$39.87
Nigeria	1	90.00	_	_	$117.52
Pakistan	2	100.00	$171.35	$171.35	$36.15 (473.99%)
Panama	1	_	$108.00	_	$958.98
Paraguay	3	50.00	$325.00 ± $247.49	$400.00	$464.09 (86.19%)

Peru	7	100.00	$1584.28	$883.39 ± $991.20	$358.58 (246.36%)
Philippines	10	100.00 ± 0.00	$764.27 ± $297.64	$485.60 ± $198.47	$135.20 (359.17%)
Romania	2	_	_	$532.94	$556.81 (95.71%)
Serbia	2	0	NA	$868.71 ± $354.25	$632.92 (137.25%)
South Africa	14	53.00 ± 41.91	$1251.08 ± $1063.39	$1716.99 ± $1474.63	$570.21 (301.11%)
Sri Lanka	1	0	NA	_	$127.33
Tunisia	1	66.00	$2853.07	$2139.80	$305.30 (700.88%)
Turkey	9	0	NA	$1549.36 ± $576.87	$567.63 (272.95%)
Venezuela	8	85.00 ± 23.80	$391.50 ± $256.95	$2972.29 ± $1978.09	$873.38 (340.32%)
LMIC Mean ± SD		*49.60 ± 38.30*	*$597.25 ± $783.03*	*$1038.26 ± $1202.81*	*$455.39 ± $401.28*
LMIC Median (Q25-Q75)		*35.00 (11.50-100.00)*	*$338.28 (100.60-814.21)*	*718.23 (337.33-1232.43)*	*$390.73 (194.01-572.45)*
Global Mean± SD		46.13 ± 38.70	$626.07 ± $946.33	$1527.84 ± $1671.11	$1803.11 ± $2166.96
Global Median (Q25-Q75)		30.00 (11.50-100.00)	$295.42 (119.64-711.045)	$945.91 (438.89-1940.42)	$901.57 (357.41-2517.51)

CR, cardiac rehabilitation; SD, standard deviation; USD, United States Dollars; Q25-Q75, 1st- 3rd quartile
§this item assessed total program costs (i.e., not itemized) and hence was likely estimated grossly by respondents. Therefore there is likely considerable measurement error which should be taken into consideration when interpreting the values.

†PPP, Purchasing Power Parity (http://eppi.ioe.ac.uk/costconversion/default.aspx)
- Response about CR cost was not provided by any respondent in the country
NA – not applicable as patients do not pay for any part of CR in this country
n/a not available

Table 2: Impact of Cardiac Rehabilitation Funding Source

n (%) or mean ± standard deviation	**Public Only**	**Private Only (insurance or patient)**	**Hybrid**	**All**	**Any Patient Funding**
Program capacity (patients / year)	522.46 ± 887.86 ‖‖	534.46 ± 923.20 †	926.98 ± 1661.00 ‖‖ †	627.32 ± 1151.93 **	768.41 ± 1473.59 *
Median (Q25-Q75)§	273.00 (120.00-510.00)	200.00 (100.00-580.00)	400.00 (200.00-900.00)	300.00 (120.00-600.00)	300.00 (128.00-700.00)
Number healthcare providers on team	5.97 ± 2.72 †	5.25±2.54 †	6.15 ± 3.10	5.88 ± 2.81 *	5.61 ± 2.82 **
Physician on team (% yes)	210 (40.50%)	80 (46.20%)	124 (52.80%)	414 (44.70%)	174 (49.00%)
Staff-to-patient ratio	1:5.15 ± 9.45	1:3.52 ± 3.19	1:5.07 ± 7.31	1:4.81 ± 8.04	1:4.29 ± 6.11
Median (Q25-Q75)	1:4.00 (3.00-5.25)	1:3.00 (2.00-4.62)	1:4.00 (2.83-5.00)	1:4.00 (2.50-5.00)	1:3.60 (2.00-5.00)
Patient receives individual consult with physician (% yes)	271 (60.0%) †	130 (81.80%) † ‖	151 (70.20%) ‖	552 (66.80%) **	246 (75.70%)
Program uses cardiopulmonary stress tests (VO_2)	352 (68.20%)	138 (77.50%) †	162 (68.10%) †	652 (70.00%) *	266 (74.30%)

Number risk factors assessed (/12)	8.48 ± 3.59	8.35 ± 3.69	8.79 ± 3.52	8.54 ± 3.59	8.87 ± 3.29
Core components delivered (/10)	7.24 ± 2.98	6.93 ± 2.92	7.33 ± 2.83	7.21 ± 2.93	7.27 ± 2.64 **
Patients monitored during exercise with telemetry (% yes)	244 (48.70%)	97 (57.10%)	170 (73.00%)	511 (56.50%)	236 (67.00%)
Patients per exercise session	9.95 ± 5.75 †††	6.10 ± 5.41 ††† ‖‖‖	9.28 ± 5.31 ‖‖‖	9.04 ± 5.76 ***	7.80 ± 5.59
Median (Q25-Q75)	9.00 (6.00-12.00)	5.00 (2.00-8.00)	8.00 (5.00-12.00)	8.00 (5.00-12.00)	6.00 (4.00-10.00)
CR dose (hours)	33.09 ± 48.70	42.11 ± 55.07	41.05 ± 60.11	37.03 ± 53.27	40.77 ± 53.71
Median (Q25-Q75)	18.00 (10.37-36.00)	28.00 (18.00-45.00)	30.00 (18.33-41.95)	24.00 (12.00-36.00)	30.00 (18.00-45.00)
Program offers alternative models (% yes)	194 (38.60%)	38 (22.10%)	51 (21.80%)	283 (31.20%)	81 (22.80%)

§median and 1st- 3rd quartile (Q25-Q75) shown where variation high (i.e., standard deviations greater than means).
Compared by funding source using Generalized Linear Mixed model adjusting for country – one model for each row.
* p<.05; ** p<.01; *** p<.001 for Generalized Mixed Models testing for overall model significance
†‖ 1 symbol p<.05; 2 symbols p<.01; 3 symbols p<.001 for pairwise comparisons

Table 3: Drivers of Program Delivery Costs, by Country Income Classification

Driver n (%) or mean ± standard deviation (median)	**High-Income** **(n=749)**	**p†**	**Low or Middle-Income** **(n=333)**	**p†**
Funding source ($2016PPP‖)		0.003		0.07
Public	$1981.20 ± 1962.69 ($1306.73)		$1262.69 ± 1275.21 ($1012.04)	
Private (incl. patients)	$1051.22 ± 963.02 ($582.66)		$1200.29 ± 1291.33 ($828.13)	
Hybrid	$2084.86 ± 1898.54 ($1513.24)		$780.38 ± 1036.84 ($517.65)	
Patients (full or partial)	184 (24.90%)	<0.001	211 (65.30%)	0.35
Yes	$1399.21 ± 1554.68 ($797.87)		$998.77 ± 1207.05 ($641.64)	

No	$2054.81 ± 1939.76 ($1408.45)		$1176.54 ± 1199.78 ($998.29)	
Program capacity (patients / year)	537.48 ± 809.79 (300.00)	0.005	806.56 ± 1623.82 (300.00)	<0.001
Number healthcare providers on team§	5.91 ± 2.78 (5.50)	0.001	5.81 ± 2.85 (5.50)	0.002
Physician on team (% yes)	227 (36.30%)	0.006	188 (61.20%)	0.06
Yes	$2486.99 ± 1914.59 ($1960.53)		$1168.82 ± 1403.41 ($731.48)	
No	$1158.00 ± 1403.94 ($716.33)		$798.66 ± 678.37 ($568.64)	
Staff-to-patient ratio	1:5.45 ± 9.58 (1:4.00)	0.19	1:3.51 ± 2.69 (1:3.00)	0.52
Patient receives individual consult with physician (% yes)	303 (54.30%)	0.001	253 (93.00%)	0.85
Yes	$2158.57 ± 1905.31 ($1668.08)		$980.50 ± 1095.68 ($702.22)	
No	$1190.50±1602.96		$822.38 ± 786.76	

	($716.33)		($474.55)	
Program has cardiopulmonary stress tests (VO_2) (% yes)	403 (63.50%)	0.002	253 (83.80%)	0.33
Yes	$1942.74 ± 1774.64 ($1440.64)		$1098.10 ± 1288.65 ($836.35)	
No	$1281.36 ± 1806.42 ($716.33)		$810.01 ± 773.99 ($585.19)	
Core components delivered (/10)	8.23 ± 1.59 (8.50)	0.01	7.68 ± 1.75 (8.00)	0.87
Patients monitored during exercise with telemetry (% yes)	341 (56.10%)	0.01	172 (57.00%)	0.26
Yes	$2199.64 ± 2050.47 ($1445.78)		$943.72 ± 1040.08 ($701.94)	
No	$1147.22 ± 1043.09 ($828.50)		$1126.70 ± 1384.41 ($718.23)	
Number patients per exercise session	9.68 ± 5.55 (8.50)	0.71	7.77 ± 6.08 (6.00)	<0.001
CR dose (hours)	35.93 ± 57.44	0.87	39.65 ± 43.51	0.68

	(22.50)		(30.00)	
Program offers alternative models (% yes)	219 (36.00%)	0.38	66 (21.50%)	0.02
Yes	$1588.30 ± 1867.82 ($800.00)		$684.68 ± 605.38 ($431.41)	
No	$1956.69 ± 1790.90 ($1516.44)		$1122.69 ± 1305.00 ($731.48)	

‖ PPP, Purchasing Power Parity (http://eppi.ioe.ac.uk/costconversion/default.aspx)
§part-time staff counted as .5.
†association with cost to deliver CR to 1 patient, using generalized linear mixed model adjusting for country.

Supplementary Table 1: Perceived expense of elements to deliver cardiac rehabilitation

Mean ± Standard Deviation‖	**High-Income (n=747)**	**Low or Middle-Income (n=335)**	**All (N=1082)§**
Front-line personnel	3.51 ± 1.25	2.83 ± 1.10	3.29 ± 1.24**
Exercise equipment	3.13 ± 1.21	3.49 ± 1.24	3.25 ± 1.23
Exercise stress testing	3.21 ± 1.33	3.27 ± 1.17	3.23 ± 1.28
Equipment/supplies for CVD risk assessment	2.84 ± 1.12	3.10 ± 1.20	2.93 ± 1.15
Space	2.76 ± 1.32	2.85 ± 1.28	2.79 ± 1.30
Patient education material	2.29 ± 0.89	2.36 ± 0.97	2.31 ± 0.92
Blood pressure assessment device	2.27 ± 0.82	2.16 ± 0.93	2.23 ± 0.86
Blood collection and lipid testing	2.42 ± 1.00	2.63 ± 1.03	2.50 ± 1.02†
Resistance training equipment	2.44 ± 0.91	2.56 ± 0.98	2.48 ± 0.93

CVD, Cardiovascular disease

‖scores range from 1="free" to 5="very expensive"

***p<.01.

†trend, p=.08

§ Compared by country income classification using generalized linear mixed model adjusting for country – one model for each row.