

Effects of cardiac rehabilitation on risk factor management and quality of life in patients with ischemic heart disease: a multicenter cross-sectional study

Siamala Sinnadurai,¹ Paweł Sowa,¹ Piotr Jankowski,² Zbigniew Gąsior,³ Dariusz A. Kosior,^{4,5} Maciej Haberka,³ Danuta Czarnecka,² Andrzej Pająk,⁶ Małgorzata Setny,⁴ Jacek Jamiołkowski,¹ Magda Łapińska,¹ Karol A. Kamiński¹

1 Department of Population Medicine and Lifestyle Diseases Prevention, Faculty of Medicine with the Division of Dentistry and Division of Medical Education in English, Medical University of Białystok, Białystok, Poland

2 Department of Cardiology, Interventional Electrophysiology and Hypertension, Institute of Cardiology, Jagiellonian University Medical College, Kraków, Poland

3 Department of Cardiology, School of Health Sciences, Medical University of Silesia, Katowice, Poland

4 Department of Cardiology and Hypertension with Electrophysiology Lab, Central Research Hospital of the Ministry of the Interior and Administration, Warsaw, Poland

5 Faculty of Medicine, Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland

6 Department of Epidemiology and Population Studies, Faculty of Health Sciences, Jagiellonian University Medical College, Kraków, Poland

KEY WORDS

cardiac rehabilitation, ischemic heart disease, propensity score matching, risk factors, secondary cardiovascular prevention

EDITORIAL

by Grace, see p. 610

Correspondence to:
Prof. Karol A. Kamiński, MD,
PhD, Department of Population
Medicine and Lifestyle Diseases
Prevention, Faculty of Medicine
with the Division of Dentistry and
Division of Medical Education in
English, Medical University of Białystok,
ul. Jerzego Waszyngtona 13A,
15-269 Białystok, Poland,
phone: + 48 85 746 86 56, email:
fizklin@wp.pl

Received: February 12, 2021.

Revision accepted: May 25, 2021.

Published online: May 31, 2021.

Pol Arch Intern Med. 2021;

131 (7-8): 617-625

doi:10.20452/pamw.16019

Copyright by the Author(s), 2021

ABSTRACT

INTRODUCTION While cardiac rehabilitation (CR) improves survival outcomes in patients with ischemic heart disease (IHD), the long-term benefits of short-term programs are still discussed.

OBJECTIVES The aim of the study was to assess the impact of CR on risk factor management in a multicenter real-life registry of patients with IHD.

PATIENTS AND METHODS We included patients aged 80 years or younger who had been hospitalized due to acute coronary syndrome or for a myocardial revascularization procedure and interviewed 6 to 18 months later. Control of risk factors was compared between patients who participated in CR and those who did not. Propensity score matching was used to account for differences in patient characteristics between the groups.

RESULTS Of 1012 interviewed patients (28.6% women), 35.6% were referred for CR and 76.1% of them completed the program. Those referred were younger ($P < 0.001$), employed ($P < 0.001$), have presented with ST-segment elevation myocardial infarction ($P < 0.001$), had hypertension ($P < 0.001$), and were current smokers ($P < 0.001$). Logistics regression revealed that patients who participated in CR were more likely to stop smoking (odds ratio [OR], 2.42; 95% CI, 1.33–4.14), achieve acceptable glucose control (OR, 1.70; 95% CI, 1.02–2.83), and better quality of life ($\beta = 0.12$; 95% CI, 0.00–0.24) compared with those who did not participate in CR.

CONCLUSIONS Cardiac rehabilitation is moderately effective if performed only once and without a continuous support program. Further efforts to increase referrals for CR in patients with IHD must be

INTRODUCTION Cardiac rehabilitation (CR) is one of the core elements of secondary prevention in patients with ischemic heart disease (IHD), aiming to improve risk factors, reduce hospital readmission, and produce a more favorable survival outcome. Two large meta-analyses of 34 and

18 randomized controlled trials have shown that CR reduces recurrent cardiovascular events and improves mortality rates in patients with myocardial infarction.^{1,2} Moreover, CR has also been shown to improve patients' quality of life and ability to return to work quickly.¹

WHAT'S NEW?

The benefits of cardiac rehabilitation (CR) programs in the management of risk factors in patients with chronic coronary syndromes is underreported in Poland. This is the first multicenter study to investigate the referral and participation patterns of CR in Poland. We found the rate of referral to CR in Poland was low, particularly in the elderly, unemployed, and in patients after elective percutaneous coronary intervention. There was a significant positive effect of CR on aspects of secondary prevention approximately 1 year after the acute coronary event or elective revascularization: smoking habit, blood glucose level, and quality of life. The observed effects may be limited by the fact that patients only participated in a single course of CR. Therefore, we suggest a single course of CR should be accompanied by a more prolonged schedule to sustain such benefits.

International guidelines recommend that all patients who have had a planned revascularization procedure or have acute coronary syndrome (ACS), chronic stable angina, or heart failure should engage in a CR program to reduce subsequent events.^{3,4} Moreover, recently revised practice guidelines urge for a “comprehensive rehabilitation” program covering a range of aspects: exercise training aimed at improving clinical profiles (optimization of blood pressure, lipid and glucose levels, and weight), healthy heart education (appropriate diet and smoking cessation), and psychological counseling to reduce stress and improve quality of life.^{3,5,6} These comprehensive efforts are intended to foster better cardiovascular risk management than could be achieved by supervised exercise alone.

In Poland, cardiovascular disease is one of the major causes of mortality, accounting for 46% of total deaths in 2010,⁷ with nearly half of these attributable to IHD. To address this serious situation, healthcare experts have been trying to promote a preventive approach through CR and lifestyle changes. In addition, there has been an increase in the efforts to manage care for patients with IHD, including increased access to CR programs.⁸ To our knowledge, there are no multicenter studies to investigate disparities in referral rates and participation in CR and the effectiveness of CR in Poland.

However, referrals for CR programs and the impact of such programs in the real world have been suboptimal⁹ both in Europe¹⁰ and the USA.¹¹ A summary of a large cross-sectional survey carried out by the pan-European group, EUROASPIRE (European Action on Secondary and Primary Prevention by Intervention to Reduce Events), reported that CR referral rates and hence participation rates in Europe remain low.^{12,13} Thus, there is the need for urgent action to increase referral and enrollment rates in CR programs.

This study assessed the effectiveness of CR in a patient population enrolled in a CR program in 14 cardiology centers from 4 different regions of Poland, all of which participated in the EUROASPIRE.

PATIENTS AND METHODS The POLASPIRE is a parallel program run by Polish centers involved in the EUROASPIRE V. In total, 403 patients chosen from the POLASPIRE survey contributed to the Polish subset of the EUROASPIRE V. The detailed methodology of this survey has been described previously.^{14,15} A multicenter cross-sectional study was conducted between 2016 and 2017 on Polish patients from 4 geographical areas (Kraków, Katowice, Warszawa, Białystok) and from 14 cardiology departments. For each department, medical records were reviewed retrospectively of patients aged between 18 and 80 years who had been hospitalized for 1) coronary artery bypass graft surgery (CABG), 2) elective percutaneous coronary intervention (PCI), 3) acute myocardial infarction (*International Classification of Diseases, Tenth Revision* codes I21 and I22), or 4) unstable angina. Eligible patients were invited for an interview and follow-up examination 6 to 18 months after being discharged. In addition to the patients from the EUROASPIRE V database, we also enrolled additional patients from participating centers during the same period, using the same methodology as well as inclusion and exclusion criteria.

All patients provided written informed consent to take part in the study. The study was approved by the local ethics committees in each regional center.

Cardiac rehabilitation management Patients were asked to report their level of participation in CR at the time of the interview using the following options: 1) did not attend; 2) attended at least one session; 3) attended more than half of the sessions; or 4) completed all of the recommended sessions. In Poland, full participation means that patients received a comprehensive program of in-hospital rehabilitation of between 2 to 6 weeks, which included exercise training, dietary guidance, medication review, smoking cessation advice, and stress management. Due to the design of the study and the short duration of enrollment, we only included participants in the treatment group who declared that they completed all of the CR sessions, to reliably assess the effects of CR.

Study variables We used interviews to obtain participants' self-reported information on a range of health and lifestyle-related issues, detailed below. Each patient's body mass index (BMI) was calculated using their height and weight measured in a straight standing position without shoes and heavy items. Obesity was defined as a BMI of 30 kg/m² or greater. A low educational level was defined as having completed only primary school level education or less. A persistent smoker was defined as a patient reported to have been a smoker in the month before the index event who was either still smoking at the time of the interview or who had levels of exhaled carbon monoxide exceeding 10 ppm. Blood pressure was

measured twice on the right arm in a sitting position at 5-minute intervals, and the mean was used for analyses. Increased blood pressure was defined as blood pressure of 140/90 mm Hg or greater. Total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides, and glycated hemoglobin (HbA_{1c}) were measured in fasting venous blood samples. An elevated LDL-C concentration was defined as 1.8 mmol/l or greater, and HbA_{1c} was considered acceptable if lower than 7%, as per the relevant guidelines.⁵ Depression and anxiety were assessed using the Hospital Anxiety and Depression Scale (HADS) with a score of less than 8 points considered normal. Quality of life was assessed using a Health-Related Quality of Life (HRQoL) questionnaire consisting of 2 domains, physical (10 items) and emotional (4 items). Generic health status was assessed using the EQ-5D questionnaire which comprises a 5-dimension code describing the patient's state of health in 5 domains, which was converted into a single index ranging from "0" (dead) to "1" (perfect health), with Germany used as the country of reference.¹⁶

Follow-up and outcome assessment The main outcome in this study was the achievement of risk factor management goals and self-reported lifestyle changes at interview. The secondary outcome was interactions between CR participation and time points.

Propensity score matching method We performed propensity score matching (PSM) to account for potential bias resulting from an imbalance in the covariate distribution between the groups that had been referred for and who participated in CR and those who were not referred and did not participate in CR, both of which could be influenced by decisions taken by physicians and patients. We used multivariable logistic regression to obtain a propensity score (PS) for each CR participant and then were able to search the database for nonreferred CR patients with the same or nearly the same PS match.¹⁷ The variables included in generating the PS were age at index event, gender, center code, type of event, education status, obesity, BMI, and smoking status.

Statistical analysis The distribution of study variables was analyzed using the Shapiro–Wilk test, with a *P* value of less than 0.05 indicating normal distribution. Categorical variables were described using proportion and compared using the χ^2 test. Continuous variables were expressed using mean and median values and compared using the Mann–Whitney test for data without a normal distribution and *t* test for variables with a normal distribution.

We used the χ^2 test to compare the distribution of the baseline characteristics of patients who had been referred for CR with those not referred for CR. Multivariable logistic regression

was used to identify predictors of CR participation in those referred for CR. Univariable logistic and linear regression models were constructed to estimate the effect of CR in those who participated in CR and those who did not participate from the dataset of propensity score-matched groups.

A generalized linear model (GLM) was used, rather than a simple linear regression model, to adequately account for correlated data due to repeated measurements (pre and post) of the same study participants. This model encompassed 3 effects: 1) CR effect describing baseline difference between those who participated in CR and those who did not, 2) time effect describing interview–baseline difference, and 3) the main effect, that is, time–CR interaction effect, which describes whether there is a different time effect in the CR group compared with the no-CR group and highlights the differences in outcome variables during follow-up between the CR groups.

The multiple imputation method was used to deal with missing values (ranging from 5% to 20%). All the variables mentioned were included in the imputation model, and 10 imputation sets were then created.^{18,19} The imputation set was used to analyze and report study outcomes in both univariable regression model and GLM.

A 2-tailed *P* value of less than 0.05, and a 95% CI for odds ratios that did not include 1, were considered statistically significant. All analyses were performed using IBM SPSS statistics software, version 25 (IBM, Armonk, New York, United States).

RESULTS We assessed 1012 patients who were interviewed 6 to 18 months after their index event and who had provided complete information on their participation in CR (TABLE 1). Of these, women accounted for less than 30% of patients. The median age of patients at the time of hospitalization was 65 years, and the majority of the patients had been hospitalized in teaching hospitals (83%). Almost 40% of the patients had been recruited following elective PCI (*n* = 377). Other common index events were: non–ST-segment elevation myocardial infarction (NSTEMI) in 217 patients (21.4%), unstable angina in 215 (21.2%), and ST-segment elevation myocardial infarction (STEMI) in 160 (15.8%) (TABLE 1). Overall, one-third of patients had been referred for a CR program (35.6%), and 76.1% of these completed all the recommended sessions.

Physicians were more likely to refer younger than older patients (median [IQR] age, 62 [57–68] years vs 67 [61–72] years, respectively), and employed as compared with unemployed patients (*P* < 0.001) to CR. The rates of CR referral and participation differed considerably between regions (FIGURE 1). Clinically, the patients referred were more likely to have presented with STEMI (*P* < 0.001), CABG (*P* < 0.001), or hypertension (*P* < 0.001), and were more likely to be taking angiotensin-converting enzyme (ACE) inhibitors (*P* < 0.001), diuretics (*P* < 0.001), and

TABLE 1 Baseline characteristics and treatment profile of patients referred and not referred for cardiac rehabilitation at the time of hospitalization (continued on the next page)

Variable		Total (n = 1012)	Cardiac rehabilitation status		P value ^a
			Not referred (n = 652)	Referred (n = 360)	
Age at index event		65 (60–71)	67 (61–72)	62 (57–68)	<0.001
Center	Nonteaching hospitals	172 (17)	114 (17.5)	58 (16.1)	0.57
	Teaching hospitals	840 (83)	538 (82.5)	302 (83.9)	
Region	Białystok	238 (23.5)	75 (11.5)	163 (45.3)	<0.001
	Kraków	398 (39.3)	296 (45.4)	102 (28.3)	
	Katowice	150 (14.8)	102 (15.6)	48 (13.3)	
	Warsaw	226 (22.3)	179 (27.5)	47 (13.1)	
Sex	Male	723 (71.4)	458 (70.2)	265 (73.6)	0.25
	Female	289 (28.6)	194 (29.8)	95 (26.4)	
Education status ^b	Primary level	125 (12.5)	84 (12.9)	41 (11.5)	0.52
	Higher level	879 (87.5)	565 (87.1)	314 (88.5)	
	Unknown	8	3	5	
Employment status	Unemployed	663 (66.1)	471 (72.2)	192 (54.7)	<0.001
	Employed	340 (33.9)	181 (27.8)	159 (45.3)	
	Unknown	9	0	9	
Index event	CABG	43 (4.2)	19 (2.9)	24 (6.7)	<0.001
	PCI	377 (37.3)	286 (43.9)	91 (25.3)	
	STEMI	160 (15.8)	56 (8.6)	104 (28.9)	
	NSTEMI	217 (21.4)	115 (17.6)	102 (28.3)	
	UA	215 (21.2)	176 (27.0)	39 (10.8)	
Previous event	CABG	75 (13.6)	58 (14.2)	17 (12)	0.5
	PCI	333 (60.8)	241 (59.2)	92 (65.2)	0.2
	AMI	255 (47)	195 (48.4)	60 (43.2)	0.28
	UA	55 (10.4)	47 (12)	8 (5.7)	0.03
	Angina pectoris	206 (39)	172 (44.1)	34 (24.6)	<0.001
	Stroke	58 (10.7)	45 (11.2)	13 (9.4)	0.55
	PAD	42 (7.8)	33 (8.2)	9 (6.4)	0.49
	Heart failure	40 (7.5)	37 (9.3)	3 (2.2)	<0.001
Smoking habit	Nonsmoker	356 (38.8)	236 (39.5)	120 (37.6)	<0.001
	Former smoker	312 (34)	225 (37.6)	87 (27.3)	
	Current smoker	249 (27.2)	137 (22.9)	112 (35.1)	
	Unknown	54	41	95	
Obesity		395 (39)	265 (40.6)	130 (36.1)	0.05
Weight, kg		82.7 (74–94)	83 (74–93)	82.5 (74–94)	0.86
BMI, kg/m ²		29 (26.2–32.2)	29 (26.2–32.1)	28.9 (26–32.6)	0.96
Diabetes		317 (31.3)	200 (30.7)	117 (32.5)	0.24
Hypertension		880 (87)	587 (90)	293 (81.4)	<0.001
SBP, mm Hg		136 (123–150)	136 (123.5–150)	135 (120.7–150)	0.18
DBP, mm Hg		80 (72–88)	80 (74–88)	80 (71–88)	0.32
Hyperlipidemia		817 (80.7)	524 (80.4)	293 (81.4)	0.51
LDL-C, mmol/l		2.4 (1.8–3.3)	2.4 (1.7–3.2)	2.5 (1.9–3.4)	<0.01
HDL-C, mmol/l		1.1 (0.9–1.3)	1.1 (0.9–1.4)	1.1 (0.9–1.3)	0.02
Triglycerides, mmol/l		1.3 (0.9–1.8)	1.2 (0.9–1.8)	1.3 (0.9–1.8)	0.38

TABLE 1 Baseline characteristics and treatment profile of patients referred and not referred for cardiac rehabilitation at the time of hospitalization (continued from the previous page)

Variable		Total (n = 1012)	Cardiac rehabilitation status		P value ^a
			Not referred (n = 652)	Referred (n = 360)	
Medication prescribed	Antiplatelets	999 (98.7)	643 (98.6)	356 (98.9)	0.71
	β-Blockers	931 (92)	599 (91.9)	332 (92.2)	0.84
	ACE inhibitors	773 (76.4)	478 (73.3)	295 (81.9)	<0.001
	Statins	960 (94.9)	614 (94.2)	346 (96.1)	0.18
	Calcium channel blockers	272 (26.9)	188 (28.8)	84 (23.3)	0.05
	Diuretics	512 (50.6)	309 (47.4)	203 (56.4)	<0.001
	Anticoagulants	147 (14.5)	114 (17.5)	33 (9.2)	<0.001

Categorical data are presented as numbers (percentages) and continuous data as medians (interquartile ranges).

a P values are reported as obtained after exclusion of missing values.

b Primary educational level denotes at most primary school level of education, higher educational level denotes completion of secondary school, high school, technical or vocational training, college, or postgraduate study.

Abbreviations: ACE, angiotensin converting enzyme; AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass graft; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; NSTEMI, non-ST-segment elevation myocardial infarction; PAD, peripheral artery disease; PCI, percutaneous coronary intervention; SBP, systolic blood pressure; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina

anticoagulants ($P < 0.001$) at the time of hospital discharge. One-third of smokers at the time of the index event (35.1%) were referred for CR ($P < 0.001$). Among the patients referred for CR, obese patients were twice as likely to participate in CR (OR, 2.32; 95% CI, 1.07–5) than the non-obese. In addition, a higher level of education was marginally associated with CR participation (OR, 2.05; 95% CI, 0.99–4.27) (TABLE 2). After PSM, we revealed that patients who participated in CR were 2-fold more likely to stop smoking (OR, 2.42; 95% CI, 1.33–4.14) and to achieve appropriate glucose control (OR, 1.70; 95% CI, 1.02–2.83) than those who did not participate in CR (TABLE 3). A marginal improvement was observed in the physical domain of the quality of life score in patients who participated in CR (β coefficient = 0.12; 95% CI, 0.00–0.24). Overall, there were no significant changes in lipid concentrations and systolic blood pressure during follow-up that were affected by CR (TABLE 4). We further performed sensitivity analyses to examine the effects of PSM compared to conventional methods, which showed that both produced very similar results.

DISCUSSION We present several findings of interest regarding CR referrals in Poland. First, the rate of referrals between 2016 and 2017 was relatively low, with only 35.6% of relevant cardiac patients referred for CR. Second, there were significant disparities in CR referral rates between regions, but little or no difference between teaching and nonteaching hospitals. Third, CR was most often recommended for those with acute myocardial infarction (STEMI, 28.9% and NSTEMI, 28.3%). Obesity was a strong predictor of participation in CR. Finally, patients who participated in CR were twice as likely to quit

smoking, achieve a favorable glucose concentration, and have an improved quality of life (in the physical domain) than those who did not take part in CR.

The challenge is that, despite growing evidence from meta-analyses, systematic reviews, and multicenter studies showing that CR improves the prognosis for IHD patients in terms of reduced hospital readmissions, recurrent events, and mortality,^{2,20–22} there is still a low acceptance of CR overall in Poland. Our results confirm that there is a huge gap in referrals and enrollments between hospital discharge and participation in CR. Only just over one-third (35.6%) of study patients were advised to participate in CR after their index cardiovascular event, of whom just under 77% completed full sessions: in other words, fewer than 30% of the study population completed the recommended CR sessions. These figures on CR participation in Poland are even lower than those in both the EUROASPIRE III and IV reports covering 27 countries in Europe, which similarly showed a low proportion of patients ($\leq 50\%$) being advised to take part in CR and only around one-third doing so.^{12,13} These differences in participation levels could be due to the patients' clinical profile, healthcare systems, and the accessibility of CR services in different countries.

Another finding from our study is that CR was most often assigned to patients with acute conditions, particularly those diagnosed with STEMI (65%) or NSTEMI (47%), while the referrals for those who had undergone planned PCI were lower (24.1%). In contrast, a study from the USA using data from the ACTION-Get registry showed that about 50% of patients were referred for CR overall, with enrollment rates of 84.5% for patients with STEMI, 75.9% for those with NSTEMI, and 60% for those having undergone PCI.²³

TABLE 2 Association between patient characteristics and participation in cardiac rehabilitation in those referred for cardiac rehabilitation

Variable		Overall (n = 360)	Did not participate in CR (n = 86)	Participated in CR (n = 274)	P value (group comparison)	Multivariable ^a OR (95% CI)
Age at diagnosis, y		62 (57–68)	62 (58–68)	62 (57–68)	0.92	0.99 (0.96–1.03)
Center	Nonteaching hospitals	58 (16.1)	18 (20.9)	40 (14.6)	0.16	1
	Teaching hospitals	302 (83.9)	68 (79.1)	234 (85.4)		1.7 (0.87–3.29)
Sex	Female	95 (26.4)	19 (22.1)	76 (27.7)	0.3	1
	Male	265 (73.6)	67 (77.9)	198 (72.3)		0.76 (0.42–1.4)
Index event	Planned revascularization	115 (31.9)	28 (32.6)	87 (31.8)	0.88	1
	ACS	245 (68.1)	58 (67.4)	187 (68.2)		1.02 (0.58–1.8)
Education status	Primary level	41 (11.5)	14 (16.5)	27 (10)	0.1	1
	Higher level	314 (88.5)	71 (83.5)	243 (90)		2.05 (0.99–4.27)
	Unknown	5	1	4		–
Occupation status	Unemployed	192 (54.7)	45 (52.9)	147 (55.3)	0.7	1
	Employed	159 (45.3)	40 (47.1)	119 (44.7)		0.9 (0.48–1.66)
	Unknown	9	8	1		–
Smoking habit	Nonsmoker or former smoker	207 (64.9)	46 (63)	161 (65.4)	0.42	1
	Current smoker	112 (35.1)	27 (37)	85 (34.6)		1.04 (0.57–1.87)
	Unknown	41	13	28		–
Hypertension	No	34 (10.4)	10 (12.5)	24 (9.7)	0.47	–
	Yes	293 (89.6)	70 (87.5)	223 (90.3)		
	Unknown	33	6	27		
Hyperlipidemia	No	29 (9)	6 (7.9)	23 (9.3)	0.69	–
	Yes	293 (91)	70 (92.1)	223 (90.7)		
	Unknown	38	10	28		
Obesity	No	159 (55)	47 (67.1)	112 (51.1)	0.01	1
	Yes	130 (45)	23 (32.9)	107 (48.9)		2.08 (1.15–3.76)
	Unknown	71	16	55		–
Diabetes	No	198 (62.9)	46 (60.5)	152 (63.6)	0.62	1
	Yes	117 (37.1)	30 (39.5)	87 (35.4)		0.8 (0.45–1.4)
	Unknown	45	10	35		–

Categorical data are presented as numbers (percentages) and continuous data are presented as median (interquartile range).

a Multivariable model adjusted for: age at index event, center, gender, index event, education status, occupation status, smoking habit, obesity, and diabetes). Missing value was treated as “unknown” subcategory in the multivariable logistics regression model.

Abbreviations: ACS, acute coronary syndrome; CR, cardiac rehabilitation; OR, odds ratio

In summary, there are significant disparities in the levels of CR referral and participation between the USA, Europe, and specifically Poland. What is not clear is whether these low referral and participation rates are due to low physician awareness of the benefits of CR, limited access to CR facilities, patients declining to participate, or a combination thereof. The fact that CR services after ACS or PCI are covered by the public healthcare system in Poland⁸ makes it all the more surprising that CR has been so underused. One possible explanation is that, as one of the fastest-aging societies in the EU with 5.9 million people aged 65 years and older,⁷ basic healthcare facilities and hospitals may face problems in managing these large numbers of patients and the costs of treatment involved. As a consequence, hospitals may try to keep the number of admissions and basic health care referrals to a minimum, and prioritize those

most in need.⁷ Also, there is evidence that poor uptake of CR may be due to the reluctance of physicians to refer patients, lack of CR facilities, and/or lack of funding.^{1,23,24} In Poland, this was the motivation for the introduction of a country-wide program of managed care after myocardial infarction, including compulsory CR programs.⁵ The hope is that this program will improve communication between physicians and patients, which in turn may improve the uptake of CR as well as optimize secondary prevention.

Further noteworthy observations from our study are that younger, employed, smoking patients, and those on ACE inhibitors were more likely to be advised to take part in CR. Advising patients in employment to participate in CR makes sense since CR can help cardiac patients to improve their condition and quality of life to a point where they can go back to work.

TABLE 3 Patient characteristics and risk factors by participation in cardiac rehabilitation at the time of hospital interview using univariable regression model

Variable	No CR (n = 274)	CR (n = 274) ^a	OR (95% CI) ^b	β coefficient (95% CI) ^c	P value
Stopped smoking ^d	31 (33)	49 (54.4)	2.42 (1.33–4.14)	–	<0.001
Physically active ^e	49 (18.6)	36 (13.7)	0.71 (0.44–1.13)	–	0.15
Body weight					
BMI <25 kg/m ²	38 (14.1)	40 (14.8)	1.07 (0.66–1.73)	–	0.76
BMI <30 kg/m ²	149 (55.2)	158 (58.5)	1.14 (0.81–1.60)	–	0.45
Weight, kg	85.8 (75.3–94.9)	85 (75–94)	–	–0.23 (–2.79 to 2.31)	0.85
BMI, kg/m ²	29.4 (26.7–32.7)	29 (26.4–32.5)	–	0.32 (–0.48 to 1.12)	0.43
Blood pressure					
BP <140/90 mm Hg	238 (87.8)	237 (87.5)	0.96 (0.57–1.61)	–	0.89
SBP, mm Hg	131 (120–146)	130 (120–145)	–	–1.06 (–4.29 to 2.16)	0.51
DBP, mm Hg	80 (73–87)	80 (73.5–87.5)	–	0.49 (–1.27 to 2.26)	0.58
Cholesterol control					
LDL-C <1.8 mmol/l	109 (40.7)	95 (35.1)	0.78 (0.55–1.11)	–	0.17
LDL-C, mmol/l	1.9 (1.54–2.6)	2 (1.6–2.59)	–	0.03 (–0.12 to 0.18)	0.7
HDL-C, mmol/l	1.23 (1.06–1.47)	1.24 (1.03–1.49)	–	–0.01 (–0.07 to 0.04)	0.58
Triglycerides, mmol/l	1.29 (0.95–1.79)	1.27 (0.91–1.76)	–	–0.05 (–0.24 to 0.14)	0.59
Glucose control					
HbA _{1c} <7%	195 (81.9)	224 (88.5)	1.7 (1.02–2.83)	–	0.04
HbA _{1c}	6 (5.6–6.4)	5.8 (5.6–6.2)	–	0.02 (–0.46 to 0.52)	0.9
Medication					
Antiplatelets	250 (92.3)	262 (95.6)	1.83 (0.88–3.8)	–	0.1
β-Blockers	235 (86.7)	248 (90.5)	1.46 (0.85–2.49)	–	0.16
ACE inhibitors	192 (70.8)	208 (75.9)	1.29 (0.88–1.89)	–	0.18
Lipid-lowering	241 (88.9)	246 (89.8)	1.09 (0.63–1.88)	–	0.74
Quality of life					
Anxiety HADS <8	8 (3)	10 (3.8)	1.25 (0.48–3.23)	–	0.63
Depression HADS <8	32 (11.9)	39 (14.7)	1.27 (0.77–2.11)	–	0.33
Emotional HRQoL	2 (1.5–2.2)	2 (1.5–2.2)	–	0 (–0.09 to 0.90)	0.94
Physical HRQoL	2.2 (1.7–2.7)	2.4 (1.8–2.8)	–	0.12 (0–0.24)	0.05
EQ-5D QoL	0.9 (0.8–0.9)	0.9 (0.8–0.9)	–	0 (–0.01 to 0.02)	0.65

Categorical data are presented as numbers (percentages) and continuous data are presented as median (interquartile range).

- a** Completed all the recommended sessions.
- b** Odds ratio reported for a propensity score-matched population.
- c** β Coefficients reported for a propensity score-matched population.
- d** For patients smoking in the month before the recruiting event.
- e** Patient exercise duration >20 minutes per week.

Abbreviations: BP, blood pressure; HbA_{1c}, glycated hemoglobin; HADS, hospital anxiety and depression scale; HRQoL, health-related quality of life; EQ-5D QoL, Euro quality of life questionnaire of 5 dimension; others, see [TABLES 1](#) and [2](#)

Concerning age, physicians are perhaps less inclined to refer the elderly for CR due to frailty and possible difficulties they might face in commuting to the hospital.^{5,25} To reduce these age-related disparities, alternative approaches such as home-based CR for elderly and frail patients should be considered and ideally included in a country-wide program.²⁶

Our findings show that more than half of the patients participating in CR were smokers, which is consistent with the results of the EUROASPIRE IV (OR, 1.48; 95% CI, 1.25–1.74).

Moreover, those participating in CR were more than twice as likely to give up smoking than non-participants. There is previous evidence from landmark trials that smoking may even outweigh the beneficial effects of statins. These studies showed that the risk of mortality observed in non-smokers not receiving statins was similar to that of smokers on statins.²⁷ Our results and those of others¹³ showing the beneficial impact of CR programs performed in individuals quitting smoking could help boost efforts to encourage more

TABLE 4 Interaction between cardiac rehabilitation participation and time point on risk factors using a generalized linear model

Parameter	No CR (n = 274)		CR (n = 274)		Interaction between CR and measurement time (95% CI)	P value ^a
	Baseline	Interview	Baseline	Interview		
Weight, kg	85.9 (15)	85.4 (15)	84.9 (4.9)	85.1 (15.3)	0.32 (−1.58 to 2.23) ^b	0.74
SBP, mm Hg	139 (20)	133 (19)	136 (21)	132 (18)	1.57 (−2.6 to 5.75) ^b	0.46
DBP, mm Hg	82 (11)	80 (10)	79 (12)	80 (10)	3.17 (0.81–5.53) ^b	<0.001
LDL-C, mmol/l	2.7 (1.3)	2.2 (1)	2.7 (1.1)	2.2 (0.9)	−0.02 (−0.25 to 0.2) ^b	0.83
HDL-C, mmol/l	1.2 (0.4)	1.2 (0.3)	1.1 (0.3)	1.2 (0.3)	0.02 (−0.05 to 0.1) ^b	0.52
Triglycerides, mmol/l	1.5 (1.2)	1.5 (1.3)	1.5 (0.9)	1.4 (0.9)	0.00 (−0.2 to 0.13) ^b	0.93
Antiplatelet agent	268 (98.9)	250 (92.3)	270 (98.5)	262 (95.6)	2.42 (0.54–10.9) ^c	0.24
β-Blocker	250 (92.3)	235 (86.7)	253 (92.3)	248 (90.5)	1.44 (0.78–2.66) ^c	0.24
ACE inhibitors	198 (73.1)	192 (70.8)	227 (82.8)	208 (75.9)	0.72 (0.47–1.11) ^c	0.14
Statin	262 (96.7)	241 (88.9)	264 (96.4)	246 (89.8)	1.2 (0.44–3.29) ^c	0.71

Categorical data are presented as numbers (percentages) and continuous data are presented as means (SD).

a P value derived from the interaction between cardiac rehabilitation and measurement time point.

b β Coefficient for continuous outcomes.

c Odds ratio for categorical outcomes.

Abbreviations: see TABLES 1 and 2

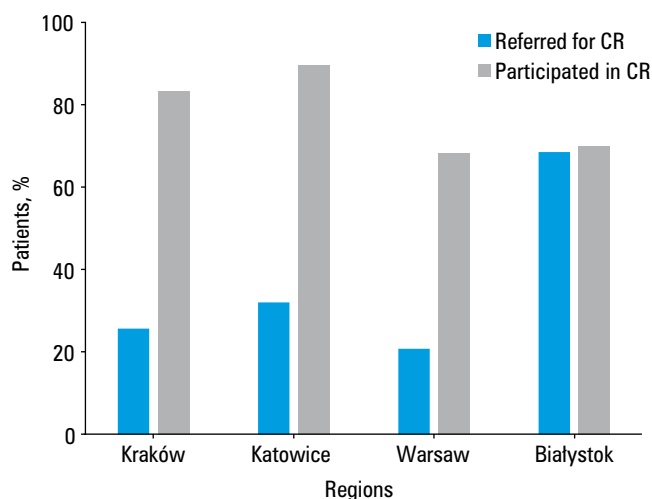


FIGURE 1 Referrals and participation in a cardiac rehabilitation (CR) program by regions. Bars labelled as “Referred for CR” show the percentage of all enrolled patients in that region who were referred to the CR center according to the discharge letter and patient history. Bars labelled as “Participated in CR” present the percent of patients who were referred for CR and who completed a full CR program.

persistent smokers to participate in CR and attend sessions regularly.

Our study confirms positive effects of CR. It showed an approximately 2-fold reduction of average blood glucose levels ($HbA_{1c} < 7\%$) in those taking part and completing all the sessions. Moreover, patients who participated in CR showed marginal increases in HRQoL in at least 1 domain. This finding is similar to 2 earlier observational studies that reported significant improvements in quality of life at 6-month²⁸ and 1-year²⁹ follow-up. However, neither of these studies adjusted for confounding factors, unlike our study, which applied comprehensive adjustments through the PSM method. Our results

therefore provide substantial novel evidence to confirm these findings. However, the observed effects on the attainment of secondary prevention targets are still smaller than expected. We need to search for innovative strategies to improve and sustain the beneficial effects of CR.³⁰

This study is subject to several limitations. The main one is potential recall bias, given that the bulk of data on CR participation and its effects was obtained from patients’ self-reported questionnaires. Another limitation is that patients volunteered to participate in the study, so individuals more concerned about their health might have been more likely to participate. Finally, since the data was gathered in Poland, the results may not be representative of all countries.

Nonetheless, our findings contribute to the evidence supporting the introduction of the managed healthcare policy for patients with IHD in Poland, which aims to increase CR uptake and participation rates in Poland as well as involving multidisciplinary teams (physicians, nurses, exercise scientists, nutritionists, and psychologists) to improve the prognosis of patients with IHD.^{8,21} Our statistical approach, using the PSM method to control confounding variables as well as systematically dealing with missing values using multiple imputations, greatly enhances the statistical power and strength of the study findings, notwithstanding the modest size of the sample groups.

Conclusions The present study showed that a relatively small number of patients with IHD are referred for CR in Poland. Most patients had an improved lifestyle after participation in CR, with the main identified long-term benefits being an increase in the rates of those giving up smoking and a better quality of life score in the physical

domain. Our findings point to an urgent need to incorporate CR into optimized long-term care programs to help sustain the benefits for patients with IHD.

ARTICLE INFORMATION

ACKNOWLEDGMENTS This research was conducted within the project which received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 754432 and the Polish Ministry of Science and Higher Education, from financial resources for science in 2018–2023 granted for the implementation of an international cofinanced project; statutory funds from the Medical University of Białystok [SUB/1/DN/19/006/1201; to SS]. The author thanks the Białystok Polish Longitudinal University Study team for study coordination and data collection.

CONTRIBUTION STATEMENT SS and KK contributed equally. KK, PJ, SS, JJ, and PS contributed to the conceptualization and design of the study. KK, PJ, ZG, DK, MH, DC, AP, MS, and ML contributed to the data acquisition and interpretation. SS, KK, PS, and JJ contributed to the data analysis and interpretation. The draft manuscript was prepared by SS and KK, and critically checked and approved by KK. All authors critically revised and approved the final manuscript.

CONFLICT OF INTEREST None declared.

OPEN ACCESS This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (CC BY-NC-SA 4.0), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material, provided the original work is properly cited, distributed under the same license, and used for noncommercial purposes only. For commercial use, please contact the journal office at pamw@mp.pl.

HOW TO CITE Sinnadurai S, Sowa P, Jankowski P, et al. Effects of cardiac rehabilitation on risk factor management and quality of life in patients with ischemic heart disease: a multicenter cross-sectional study. *Pol Arch Intern Med.* 2021; 131: 617-625. doi:10.20452/pamw.16019

REFERENCES

- 1 Lawler PR, Filion KB, Eisenberg MJ. Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: a systematic review and meta-analysis of randomized controlled trials. *Am Heart J.* 2011; 162: 571-584. e2. [↗](#)
- 2 van HG, Deckers J, Tay HY, et al. Lessons from contemporary trials of cardiovascular prevention and rehabilitation: a systematic review and meta-analysis. *Int J Cardiol.* 2017; 232: 294-303. [↗](#)
- 3 Piepoli MF, Hoes AW, Agewall S, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts) Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J.* 2016; 37: 2315-2381.
- 4 Smith SC, Benjamin EJ, Bonow RO, et al. AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation endorsed by the World Heart Federation and the Preventive Cardiovascular Nurses Association. *J Am Coll Cardiol.* 2011; 58: 2432-2446. [↗](#)
- 5 Piepoli MF, Corra U, Adamopoulos S, et al. Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery: a policy statement from the cardiac rehabilitation section of the European Association for Cardiovascular Prevention & Rehabilitation. Endorsed by the Committee for Practice Guidelines of the European Society of Cardiology. *Eur J Prev Cardiol.* 2014; 21: 664-681.
- 6 Balady GJ, Ades PA, Comoss P, et al. Core components of cardiac rehabilitation/secondary prevention programs. A statement for healthcare professionals from the American Heart Association and the American Association of Cardiovascular and Pulmonary Rehabilitation Writing Group. *Circulation.* 2000; 102: 1069-1073. [↗](#)
- 7 Nieszporska S. Priorities in the Polish health care system. *Eur J Health Econ.* 2017; 18: 1-5. [↗](#)
- 8 Jankowski P, Gasior M, Gierlotka M, et al. Coordinated care after myocardial infarction. The statement of the Polish Cardiac Society and the Agency for Health Technology Assessment and Tariff System. *Kardiologia Pol.* 2016; 74: 800-811. [↗](#)
- 9 Jankowski P, Pajak A, Lysek R, et al. Cardiac rehabilitation in real life. *Medicine.* 2015; 94: E1257. [↗](#)
- 10 Kotseva K, Gerler L, Sidelnikov E, et al. Patient and caregiver productivity loss and indirect costs associated with cardiovascular events in Europe. *Eur J Prev Cardiol.* 2019; 26: 1150-1157. [↗](#)
- 11 Mazzini MJ, Stevens GR, Whalen D, et al. Effect of an American Heart Association Get With the Guidelines Program-based clinical pathway on

referral and enrollment into cardiac rehabilitation after acute myocardial infarction. *Am J Cardiol.* 2008; 101: 1084-1087. [↗](#)

12 Kotseva K, Wood D, De Backer G, De Bacquer D. Use and effects of cardiac rehabilitation in patients with coronary heart disease: results from the EUROASPIRE III survey. *Eur J Prev Cardiol.* 2013; 20: 817-826. [↗](#)

13 Kotseva K, Wood D, De Bacquer D. Determinants of participation and risk factor control according to attendance in cardiac rehabilitation programmes in coronary patients in Europe: EUROASPIRE IV survey. *Eur J Prev Cardiol.* 2018; 25: 1242-1251. [↗](#)

14 Jankowski P, Kosior DA, Sowa P, et al. Secondary prevention of coronary artery disease in Poland. Results from the POLASPIRE survey. *Cardiol J.* 2020; 27: 533-540. [↗](#)

15 Haberka M, Jankowski P, Kosior DA, et al. Treatment goal attainment for secondary prevention in coronary patients with or without diabetes mellitus – Polish multicenter study POLASPIRE. *Arch Med Sci.* 2020 Jan 23. [Epub ahead of print]. [↗](#)

16 Van HB, Janssen MF, Feng YS, et al. Interim scoring for the EQ-5D-5L: mapping the EQ-5D-5L to EQ-5D-3L value sets. *Value Health.* 2012; 15: 708-715. [↗](#)

17 Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika.* 1983; 70: 41-55. [↗](#)

18 Sterne JA, White IR, Carlin JB, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ.* 2009; 338: B2393. [↗](#)

19 Mitra R, Reiter JP. A comparison of two methods of estimating propensity scores after multiple imputation. *Stat Methods Med Res.* 2016; 25: 188-204. [↗](#)

20 Sumner J, Harrison A, Doherty P. The effectiveness of modern cardiac rehabilitation: a systematic review of recent observational studies in non-attenders versus attenders. *PLoS One.* 2017; 12: e0177658. [↗](#)

21 Wita K, Wilkosz K, Wita M, et al. Managed Care after Acute Myocardial Infarction (MC-AMI) - a Poland's nationwide program of comprehensive post-MI care - improves prognosis in 12-month follow-up. Preliminary experience from a single high-volume center. *Int J Cardiol.* 2019; 296: 8-14. [↗](#)

22 Pajak A, Wolfshaut-Wolak R, Doryńska A, et al. Longitudinal effects of a nurse-managed comprehensive cardiovascular disease prevention program for hospitalized coronary heart disease patients and primary care high-risk patients. *Kardiologia Pol.* 2020; 78: 429-437. [↗](#)

23 Aragam KG, Dai D, Neely ML, et al. Gaps in referral to cardiac rehabilitation of patients undergoing percutaneous coronary intervention in the United States. *J Am Coll Cardiol.* 2015; 65: 2079-2088. [↗](#)

24 Balady GJ, Ades PA, Bittner VA, et al. Referral, enrollment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: a presidential advisory from the American Heart Association. *Circulation.* 2011; 124: 2951-2960. [↗](#)

25 West RR, Jones DA, Henderson AH. Rehabilitation after myocardial infarction trial (RAMIT): multi-centre randomised controlled trial of comprehensive cardiac rehabilitation in patients following acute myocardial infarction. *Heart.* 2012; 98: 637-644. [↗](#)

26 Vigorito C, Abreu A, Ambrosetti M, et al. Frailty and cardiac rehabilitation: a call to action from the EAPC Cardiac Rehabilitation Section. *Eur J Prev Cardiol.* 2017; 24: 577-590. [↗](#)

27 Milionis HJ, Rizos E, Mikhailidis DP. Smoking diminishes the beneficial effect of statins: observations from the landmark trials. *Angiology.* 2001; 52: 575-587. [↗](#)

28 Aldana SG, Whitmer WR, Greenlaw R, et al. Cardiovascular risk reductions associated with aggressive lifestyle modification and cardiac rehabilitation. *Heart Lung.* 2003; 32: 374-382. [↗](#)

29 Espinosa CS, Bravo Navas JC, Gomez-Doblas JJ, et al. Postmyocardial infarction cardiac rehabilitation in low risk patients. Results with a coordinated program of cardiological and primary care. *Rev Esp Cardiol.* 2004; 57: 53-59. [↗](#)

30 Ivers NM, Schwalm JD, Bouck Z, et al. Interventions supporting long term adherence and decreasing cardiovascular events after myocardial infarction (ISLAND): pragmatic randomised controlled trial. *BMJ.* 2020; 369: 1136-1731. [↗](#)