ORIGINAL RESEARCH

Current state of cardiac rehabilitation in Germany: patient characteristics, risk factor management and control status, by education level

Kurt Bestehorn[1]
Christina Jannowitz[2]
Martin Horack[3]
Barbara Karmann[2]
Martin Halle[4]
Heinz Völler[5]

[1]Institute for Clinical Pharmacology, Technical University, Dresden; [2]Medical Department, MSD Sharp and Dohme GmbH, Haar; [3]Institut für Herzinfarktforschung Ludwigshafen an der Universität Heidelberg, Ludwigshafen; [4]Center for Prevention and Sports Medicine, Technical University, Munich; [5]Klinik am See, Rehabilitation Center for Cardiovascular Diseases, Rüdersdorf, Germany

Correspondence: Kurt Bestehorn
Institute for Clinical Pharmacology,
Technical University of Dresden,
FiedLerstrasse 27, D-01307 Dresden,
Germany
Tel +49 351 458 2815
Fax +49 351 458 4341
Email kurt.bestehorn@googlemail.de

Background: After the acute hospital stay, most cardiac patients in Germany are transferred for a 3–4-week period of inpatient cardiac rehabilitation. We aim to describe patient characteristics and risk factor management of cardiac rehabilitation patients with a focus on drug treatment and control status, differentiated by education level (low level, elementary school; intermediate level, secondary modern school; high level, grammar school/university).

Methods: Data covering a time period between 2003 and 2008 from 68,191 hospitalized patients in cardiac rehabilitation from a large-scale registry (Transparency Registry to Objectify Guideline-Oriented Risk Factor Management) were analyzed descriptively. Further, a multivariate model was applied to assess factors associated with good control of risk factors.

Results: In the total cohort, patients with a manifestation of coronary artery disease (mean age 63.7 years, males 71.7%) were referred to cardiac rehabilitation after having received percutaneous coronary intervention (51.6%) or coronary bypass surgery (39.5%). Statin therapy increased from 76.3% at entry to 88.9% at discharge, and low density lipoprotein cholesterol < 100 mg/dL rates increased from 31.1% to 69.6%. Mean fasting blood glucose decreased from 108 mg/dL to 104 mg/dL, and mean exercise capacity increased from 78 W to 95 W. Age and gender did not differ by education. In contrast with patients having high education, those with low education had more diabetes, hypertension, and peripheral arterial disease, had lower exercise capacity, and received less treatment with statins and guideline-orientated therapy in general. In the multivariate model, good control was significantly more likely in men (odds ratio 1.38; 95% confidence interval 1.30–1.46), less likely in patients of higher age (0.99; 0.99–0.99), with diabetes (0.90; 0.85–0.95), or peripheral arterial disease (0.88; 0.82–0.95). Compared with a low level education, a mid level education was associated with poor control (0.94; 0.89–0.99), while high education did not have a significant effect (1.08; 0.99–1.17).

Conclusion: Patients with different levels of education treated in cardiac rehabilitation did not differ relevantly in terms of demographics, but did differ in some clinical aspects. With respect to the ultimate goal of cardiac rehabilitation, ie, optimal control of risk factors, education level does not play an important role.

Keywords: cardiac rehabilitation, registry, inpatients, educational level, factor analysis, risk factor, lipids, diabetes, hypertension

Introduction

Patients are encouraged to embark on a cardiac rehabilitation program after an acute cardiac event, such as a non-ST elevation myocardial infarction (NSTEMI), ST elevation myocardial infarction (STEMI) followed by coronary surgery or intervention, or acute

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coronary syndrome, ie, unstable angina pectoris. This is conducted in specialized and certified hospitals, and usually lasts 3–4 weeks.[1] Intervention programs aim to increase activity levels, improve nutrition, optimize pharmacological therapy, minimize risk factors, and address psychological issues. Cardiac rehabilitation is as cost-effective as coronary artery bypass grafting[2] and can reduce mortality by up to 25%.[3–5]

In recent years, outcomes research on the effectiveness of cardiovascular interventions has increasingly addressed socioeconomic factors, including the education level of patients.[6,7] It has been a matter of debate as to whether the patient's education affects the various phases of these programs (referral, intervention, and long-term follow-up). Previous studies have been diverse in that they have investigated different countries and settings (eg, outpatient and inpatient cardiac rehabilitation), are partly outdated, and results are heterogeneous.[8]

In Germany, the transfer of cardiac patients from hospital to the cardiac rehabilitation clinic is an established procedure with low barriers. Thus, the situation allows analysis of therapeutic effectiveness under real practice conditions.[1,9] We used this setting to investigate whether patients in cardiac rehabilitation with various levels of education differ in terms of demographic or clinical patient characteristics, risk factor management including drug treatment, or control of risk factors.

Methods
Source of data
The Transparency Registry to Objectify Guideline-Oriented Risk Factor Management (TROL) is a noninterventional program initiated in 2003 in cardiac rehabilitation clinics throughout Germany.[10,11] Participating physicians documented cardiac rehabilitation inpatients on standardized case report forms. The ethics committee of the Bavarian Physician Chamber approved the registry, and all patients provided informed consent. Patient data protection was closely observed. We report an analysis of the 2003–2008 dataset, which comprises 68,191 patients with information on education level.

Variables
During the observation period, the education level was documented as follows: low level education (elementary school, corresponding to nine-year education), mid level (secondary modern school, corresponding to 10-year education), and high level (grammar school/university, corresponding to at least a 13-year school education, and

facultative university diploma). Patient characteristics were also recorded, ie, age, gender, body mass index, length of stay at the rehabilitation hospital, risk factors (diabetes mellitus, hyperlipoproteinemia, arterial hypertension, smoking, family history for cardiac disease), concomitant diseases (peripheral arterial disease, previous stroke [first reporting year 2005]), systolic and diastolic blood pressure at entry and discharge, laboratory parameters at entry and discharge (total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol, triglycerides, fasting blood glucose), cardiopulmonary exercise testing, and medication use at entry and discharge (statins, acetylsalicylic acid, beta-blockers, angiotensin-converting enzyme inhibitors, and other drugs).

Statistical analysis
Data are presented as absolute numbers, percentages, or means with standard deviations. The frequencies of categorical variables in subgroups were compared by the Chi-square or Kruskal Wallis test. Continuous variables were compared by the two-tailed Wilcoxon rank sum test. No Bonferroni adjustment was made for this post hoc specified analysis. Percentages were calculated on the basis of patients with data for each respective parameter (ie, no percentages for missing values provided).

The effect of education level on risk factor control was evaluated in a multivariate logistic regression model including age (in 10-year steps), gender, diabetes mellitus, smoking, peripheral arterial disease, body mass index $<30 \text{ kg/m}^2$, and education. The latter variable included all three levels (low, mid, high level education), and mid level and high level education were compared with low level education. No interaction between predictor variables was noted. The dependent variable was good control, defined as improvement of low density lipoprotein cholesterol and blood pressure during cardiac rehabilitation and achievement of low density lipoprotein cholesterol $<100 \text{ mg/dL}$ and systolic blood pressure $\leq130 \text{ mmHg}$. For each variable, the odds ratio to obtain good control was calculated as a point estimate and 95% confidence interval. P values ≤0.05 in two-sided tests were considered significant. The analysis was performed using SAS 9.1 (SAS Institute Inc, Cary, NC).

Results
Patient demographics and characteristics
In total, 68,191 patients with information on education level were available. Cardiac rehabilitation was undertaken in an inpatient setting in 96.9% and in an outpatient setting in

1.3% (not reported in the remaining cases). Mean duration of rehabilitation was 22.0 ± 40.2 days, with decreased variance in the last documented years of 2007 and 2008. Almost two thirds of patients were retired (60.0%). Patients with elementary school education were the largest group (59.0%), followed by secondary school education (23.6%), and grammar school/university degree (9.6%). Education was not specified in 7.7%.

Demographic and clinical characteristics are summarized in Table 1. The average age was 63.7 years, the proportion of males was 71.7%, and the mean body mass index was 28.0 kg/m². Cardiovascular risk factors were highly prevalent as expected, in particular dyslipidemia (95.6%), diabetes mellitus (32.8%), arterial hypertension (83.4%), and former or current smoking (45.5% and 16.8%, respectively). In addition to coronary artery disease, 12.2% of patients had peripheral arterial disease and 8.8% had a history of stroke.

Patients with STEMI were the largest group (43.3%), followed by NSTEMI (18.4%) and unstable angina pectoris (18.3%). In terms of therapy in the acute hospital setting, percutaneous coronary intervention was more often reported than coronary artery bypass grafting (51.6% versus 39.5%, respectively). Due to the large sample size, statistically significant differences ($P < 0.0001$) were noted for all demographic and clinical characteristics. Diabetes, previous smoking, and peripheral arterial disease were reported less frequently, and percutaneous coronary interventions more frequently, in patients with high education than in patients with low education.

Medication

Drug treatment at entry and discharge is shown in Table 2. In the overall population, statins were prescribed at entry to the majority of patients (any drug in 76.3%). In particular simvastatin (48.9%, mean dose 28.6 mg), atorvastatin (13.7%, mean dose 24.3 mg) and fluvastatin (6.6%, mean dose 59.9 mg). At the end of cardiac rehabilitation, rates of simvastatin use had increased, while atorvastatin, pravastatin, and fluvastatin use was reported somewhat less frequently. Overall, the mean dosages of these agents had slightly increased. Cholesterol absorption inhibitor prescriptions substantially increased during cardiac rehabilitation (from 5.6% to 43.6%). Aspirin use remained nearly unchanged at a high level (at discharge 82.5%), while clopidogrel use alone or in combination with aspirin slightly decreased. Angiotensin-converting enzyme inhibitors and angiotensin receptor blockers were frequently used in this registry (73.4% and 13.9%, respectively, at discharge). By education level, generally no major differences were noted for the distribution of the various statins or the mean doses at

entry or at discharge. However, in patients with high education, lower rates of angiotensin-converting enzyme inhibitors and higher rates of angiotensin receptor blockers, respectively, were reported, along with lower rates of insulin.

Target level attainment

Lipid levels, other surrogate parameters, and target level attainment rates at entry and at discharge are shown in Table 3. In the overall population, mean total cholesterol at entry was 192.1 mg/dL, mean low density lipoprotein cholesterol was 118.8 mg/dL, mean high density lipoprotein cholesterol was 43.5 mg/dL, and mean triglycerides were 160.9 mg/dL.

At discharge, lipid parameters had considerably improved (total cholesterol 158.0 mg/dL, mean low density lipoprotein cholesterol 89.4 mg/dL, mean high density lipoprotein cholesterol 43.9 mg/dL, and mean triglycerides 139.1 mg/dL). Consequently, between entry and discharge, control of lipid parameters had improved substantially. At discharge, the low density lipoprotein cholesterol goal of <100 mg/dL was achieved by 69.6% (entry 31.1%), total cholesterol <200 mg/dL by 88.1% (entry 60.1%), high density lipoprotein cholesterol >50 mg/dL in women or >40 mg/dL in men by 46.4% (entry 44.5%), and triglycerides <150 mg/dL by 66.8% (54.2% at entry). Mean systolic and diastolic blood pressure decreased to 122/73 mmHg (131/77 mmHg at entry), and exercise capacity increased to 95 W (78 W at entry). Fasting blood glucose values decreased to 104 mg/dL (108 mg/dL at entry).

When assessed by education level, target attainment levels were slightly lower in patients with low education compared with those having high education (for example, low density lipoprotein cholesterol <100 mg/dL in 69.0% versus 72.0%). Effects on blood pressure or HbA1c did not differ substantially across groups. Exercise capacity was lower in patients with low education compared with high education (90 W versus 109 W).

Factors associated with good control

Table 4 shows the multivariate model for the association of various factors with good control. Good control status was significantly more likely in men (odds ratio 1.38), and less likely in the presence of higher age (0.99), diabetes mellitus (0.89), and peripheral arterial disease (0.88), while education did not have an important role (compared with low level education as reference; mid level 0.94, ie, slightly reduced odds for good control, high level 1.01, ie, with no significant effect).

Table 1 Demographic and clinical factors, by education level

Parameter	Total n = 68,191	Low education level n = 40,266	Intermediate education level n = 16,110	High education level n = 6549	Other/unspecified n = 5266
Demographics					
Age, years	63.7 ± 11.6	64.5 ± 11.5	61.3 ± 11.6	62.9 ± 11.1	66.7 ± 11.1
Gender, male	71.7%	68.4%	73.7%	86.5%	65.3%
Body mass index, kg/m^2	28.0 ± 4.6	28.3 ± 4.7	27.3 ± 4.3	27.2 ± 4.1	28.0 ± 4.7
Diagnosis for CR					
STEMI	43.3% (29,496/68,191)	42.5% (17,101/40,266)	46.3% (7466/16,110)	44.1% (2890/6549)	38.7% (2039/5266)
NSTEMI	18.4% (12,566/68,191)	17.9% (7225/40,266)	19.2% (3100/16,110)	18.4% (1204/6549)	19.7% (1037/5266)
Unstable angina pectoris	18.3% (12,462/68,191)	19.2% (7741/40,266)	18.3% (2952/16,110)	18.9% (1241/6549)	10.0% (528/5266)
Therapy in acute hospital					
Percutaneous coronary intervention	51.6% (33,377/64,670)	49.4% (18,718/37,856)	56.1% (8694/15,493)	54.6% (3452/6318)	50.2% (2513/5003)
Coronary artery bypass surgery	39.5% (25,784/65,313)	40.0% (15,392/38,451)	37.0% (5737/15,506)	39.4% (2484/6306)	43.0% (2171/5050)
Risk factors					
Diabetes mellitus	32.8% (21,903/66,793)	36.4% (13,967/39,431)	28.0% (4417/15,760)	25.4% (1621/6390)	36.4% (1898/5212)
Dyslipidemia	95.6% (64,905/67,877)	96.2% (38,571/40,092)	95.6% (15,316/16,016)	94.1% (6141/6526)	93.0% (4877/5243)
Arterial hypertension	83.4% (56,530/67,811)	84.7% (33,901/40,030)	80.8% (12,939/16,016)	81.6% (5314/6515)	83.4% (4376/5250)
Smoking, current	16.8% (11,143/66,367)	16.8% (6596/39,197)	18.4% (2874/15,620)	15.5% (984/6368)	13.3% (689/5182)
Smoking, previous	45.5% (29,967/65,815)	44.3% (17,252/38,969)	48.8% (7532/15,431)	49.3% (3101/6291)	40.6% (2082/5124)
Peripheral arterial disease	12.2% (8177/66,987)	13.5% (5310/39,474)	10.5% (1670/15,861)	9.1% (598/6451)	11.7% (608/5201)
Previous stroke	8.8% (3963/45,162)	9.2% (2443/26,469)	7.5% (757/10,102)	8.1% (309/3899)	9.5% (454/4758)
Family history of CV disease	31.3% (20,720/66,099)	30.8% (11,990/38,962)	33.9% (5323/15,713)	34.4% (2188/6362)	24.1% (1219/5062)

Notes: Frequencies of categorical variables in subgroups were compared by Chi-square or Kruskal Wallis test. Continuous variables were compared by two-tailed Wilcoxon rank sum test. Due to the very large sample, for all reported items, differences between groups were highly significant (all P values <0.0001).
Abbreviations: STEMI, ST elevation myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; CR, cardiac rehabilitation; CV, cardiovascular.

Table 2 Drug treatment at entry and discharge, by education status

Parameter at entry and discharge	Total n = 68,191	Low education level n = 40,266	Intermediate education level n = 16,110	High education level n = 6549	Other/unspecified n = 5266	P value*
Statins, any (%)	76.3 → 88.9	75.3 → 88.9	78.1 → 89.1	79.1 → 86.6	75.1 → 90.8	<0.0001 → <0.0001
Simvastatin	48.9 → 68.4	48.7 → 69.1	47.2 → 66.2	47.0 → 61.0	57.9 → 78.8	<0.0001 → <0.01
Dose	28.6 ± 12.4 → 29.4 ± 13.5	28.5 ± 12.5 → 29.4 ± 13.5	29.0 ± 12.5 → 29.7 ± 13.9	28.5 ± 12.5 → 29.6 ± 13.5	29.0 ± 12.3 → 28.6 ± 12.7	<0.0001 → <0.0001
Pravastatin	6.1 → 4.3	6.3 → 4.5	6.2 → 4.3	6.2 → 4.7	4.3 → 2.8	<0.0001 → <0.05
Dose	26.8 ± 12.3 → 29.1 ± 12.8	26.4 ± 11.8 → 28.8 ± 11.4	26.9 ± 12.8 → 29.3 ± 15.1	26.2 ± 13.7 → 29.2 ± 15.1	30.8 ± 12.1 → 31.5 ± 11.8	<0.0001 → <0.0001
Atorvastatin	13.7 → 11.1	13.3 → 10.6	15.2 → 12.4	17.9 → 15.3	7.4 → 5.7	<0.0001 → <0.001
Dose	24.3 ± 15.1 → 25.1 ± 15.0	23.5 ± 14.1 → 24.4 ± 14.1	25.3 ± 16.3 → 26.3 ± 16.6	25.3 ± 16.3 → 25.5 ± 15.3	25.8 ± 14.7 → 25.2 ± 14.5	<0.0001 → <0.0001
Fluvastatin	6.6 → 4.4	6.0 → 4.0	8.4 → 5.5	6.5 → 4.7	5.3 → 3.4	<0.0001 → <0.34
Dose	59.9 ± 22.0 → 59.8 ± 22.0	53.8 ± 23.3 → 58.8 ± 22.2	57.1 ± 22.6 → 60.2 ± 21.8	53.8 ± 23.3 → 58.8 ± 22.2	57.4 ± 22.4 → 60.4 ± 21.7	<0.0001 → <0.36
Other statin	1.2 → 1.6	1.2 → 1.5	1.2 → 2.0	1.7 → 1.8	0.3 → 0.5	0.45 → <0.0001
Dose	35.5 ± 30.8 → 23.4 ± 24.2	35.5 ± 31.0 → 23.3 ± 24.0	36.7 ± 32.2 → 22.8 ± 23.4	31.6 ± 26.6 → 26.2 ± 28.0	45.4 ± 31.1 → 14.6 ± 11.3	<0.0001 → <0.0001
CAI	5.6 → 43.6	5.5 → 43.8	5.7 → 44.7	5.5 → 41.2	5.5 → 41.5	0.76 → <0.0001
Aspirin	83.0 → 82.5	82.6 → 82.4	84.4 → 83.2	83.6 → 81.7	81.5 → 82.0	<0.0001 → <0.05
Clopidogrel	46.9 → 43.0	44.9 → 40.8	51.0 → 47.1	50.0 → 47.3	45.7 → 42.0	<0.0001 → <0.0001
Aspirin + clopidogrel	43.4 → 38.7	41.7 → 37.0	47.2 → 42.4	44.9 → 40.4	42.5 → 38.5	<0.0001 → <0.0001
Beta-blocker	85.1 → 89.0	84.1 → 88.4	86.6 → 89.9	86.5 → 89.5	85.7 → 89.8	<0.0001 → <0.0001
ACE inhibitor	70.8 → 73.4	71.3 → 74.5	71.1 → 73.0	66.5 → 67.0	71.7 → 74.9	<0.0001 → <0.0001
ARB	10.6 → 13.9	9.7 → 12.7	11.5 → 14.9	14.0 → 18.9	10.2 → 13.5	<0.0001 → <0.0001
Oral antidiabetic drug	14.5 → 16.0	15.7 → 17.2	12.5 → 13.8	11.3 → 12.8	15.2 → 18.0	<0.0001 → <0.0001
Insulin	11.1 → 11.5	12.2 → 12.6	9.0 → 9.2	8.1 → 8.6	13.2 → 13.2	<0.0001 → <0.0001

Notes: Values are percentages at entry and → at discharge. Mean doses are provided with standard deviation. *Frequencies of categorical variables in subgroups were compared by Chi-square or Kruskal Wallis test. Continuous variables were compared by two-tailed Wilcoxon rank sum test.
Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CAI, cholesterol absorption inhibitor.

Table 3 Outcomes and guideline achievement at entry and discharge, by education level

Parameter at entry and discharge	Total n = 68,191	Low education level n = 40,266	Intermediate education level n = 16,110	High education level n = 6549	Other/unspecified n = 5266	P value*
Total cholesterol (mg/dL)	192.1 ± 47.5 → 158.0 ± 35.9	193.3 ± 47.7 → 158.8 ± 36.1	193.0 ± 46.9 → 157.5 ± 35.3	187.1 ± 46.8 → 154.3 ± 34.9	186.3 ± 47.5 → 157.6 ± 37.7	<0.0001 → <0.0001
LDL-C (mg/dL)	118.8 ± 38.4 → 89.4 ± 28.2	119.7 ± 38.3 → 90.0 ± 28.2	119.7 ± 38.5 → 89.0 ± 28.2	115.9 ± 38.1 → 87.3 ± 27.5	112.9 ± 38.9 → 88.3 ± 29.2	<0.0001 → <0.0001
HDL-C (mg/dL)	43.5 ± 12.8 → 43.9 ± 12.1	43.7 ± 12.9 → 43.9 ± 12.2	43.5 ± 13.0 → 44.2 ± 12.2	42.6 ± 12.6 → 43.5 ± 11.9	42.9 ± 12.0 → 42.9 ± 11.4	<0.0001 → <0.0001
Triglycerides (mg/dL)	160.9 ± 80.6 → 139.1 ± 67.0	161.8 ± 81.3 → 140.0 ± 67.7	161.6 ± 80.1 → 139.0 ± 64.7	156.3 ± 78.1 → 133.9 ± 63.5	157.4 ± 79.3 → 138.9 ± 72.9	<0.0001 → <0.0001
Guideline achievement at entry and at discharge (%)						
LDL-C < 100 mg/dL	31.1 → 69.6	30.1 → 69.0	29.7 → 70.4	33.5 → 72.0	39.5 → 69.8	<0.0001 → <0.0001
TC < 200 mg/dL	60.1 → 88.1	59.1 → 87.6	59.5 → 89.0	64.3 → 89.6	64.6 → 87.9	<0.0001 → <0.0001
HDL-C > 50 mg/dL (women)/> 40 mg/dL (men)	44.5 → 46.4	44.5 → 45.4	44.9 → 48.3	46.7 → 50.8	41.5 → 41.5	<0.0001 → <0.0001
Triglycerides < 150 mg/dL	54.2 → 66.8	53.9 → 66.3	53.2 → 66.8	56.7 → 68.5	57.1 → 68.8	<0.0001 → <0.001
Systolic/diastolic BP at entry and discharge (mmHg)	130.8 ± 20.3/77.1 ± 11.6 → 122.4 ± 14.4/ 73.1 ± 9.2	131.8 ± 20.3/77.4 ± 11.7 → 123.0 ± 14.5/ 73.3 ± 9.3	129.5 ± 19.9/77.0 ± 11.3 → 121.1 ± 13.7/ 73.0 ± 8.9	128.8 ± 20.3/76.7 ± 11.4 → 120.9 ± 13.7/ 72.9 ± 8.9	130.2 ± 21.1/75.3 ± 11.9 → 123.4 ± 16.0/ 71.9 ± 9.7	<0.0001 → <0.0001 / <0.0001 → <0.0001
HbA1c (%)	6.5 ± 1.1	6.5 ± 1.1	6.3 ± 1.1	6.3 ± 1.1	6.6 ± 1.1	<0.0001
Creatinine (mg/dL)	1.2 ± 0.8 → 1.2 ± 0.8	1.2 ± 0.8 → 1.2 ± 0.9	1.1 ± 0.7 → 1.1 ± 0.7	1.1 ± 0.7 → 1.2 ± 0.7	1.2 ± 0.7 → 1.2 ± 0.8	<0.0001 → <0.0001
Fasting blood glucose (mg/dL)	107.7 ± 31.9 → 103.9 ± 26.0	108.8 ± 32.5 → 104.7 ± 26.5	104.9 ± 29.3 → 101.6 ± 23.0	104.2 ± 29.1 → 99.4 ± 22.3	110.4 ± 36.4 → 109.0 ± 31.9	<0.0001 → <0.0001
Maximum exercise (W)	77.8 ± 37.7 → 94.6 ± 40.0	72.8 ± 36.5 → 89.5 ± 38.4	83.5 ± 37.7 → 101.9 ± 40.1	90.0 ± 40.0 → 109.4 ± 42.7	80.4 ± 37.0 → 90.6 ± 40.9	<0.0001 → <0.0001

Notes: HbA1c was measured at entry only. *The frequencies of categorical variables in subgroups were compared by chi square or Kruskal Wallis test. Continuous variables were compared by two-tailed Wilcoxon rank sum test.
Abbreviations: LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; TC, total cholesterol; BP, blood pressure.

Table 4 Factors associated with good control in the multivariate regression model

Parameter	OR	95% CI
Age (10-year intervals)	0.99	0.99, 0.99
Gender (male, female)	1.38	1.30, 1.46
Diabetes mellitus	0.90	0.85, 0.95
Current smoking	0.96	0.90, 1.02
Peripheral arterial disease	0.88	0.82, 0.95
BMI ≤ 30 kg/m^2	0.91	0.86, 0.96
Mid level education[a]	0.94	0.89, 0.99
High level of education[a]	1.01	0.94, 1.09

Notes: A total of 49,907 observations was used in this model. Good control was defined as attainment of LDL-C < 100 mg/dL and blood pressure $\leq 130/80$ mmHg at end of cardiac rehabilitation, and improvement of these values during cardiac rehabilitation. The c statistic, which measures how well the model predicts which parameters are more likely to result in good control, was 0.56. For further explanation of the model, please refer to the methods section. [a] Versus low level education.
Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

Discussion

TROL is one of the largest registries on cardiac rehabilitation and has been used, among others, for the description of secular trends in the management of patients in "real-world" rehabilitation.[7] The present analysis (2003–2008) provides insight into the effects of education on selected patient characteristics, cardiac drug treatments, and risk factor management, and is, to our knowledge, one of only few studies of its kind. Regarding the main outcomes, in the descriptive analysis of the subgroups there were only limited differences between patients with low, moderate, and high education with respect to characteristics, drug treatment, and outcomes (the highly significant *P* values in the comparison of groups due to the large sample are somewhat misleading in this context). Considering the effect of the intervention, the remarkable fact is that the changes are very similar, regardless of the baseline differences. While patients with low education (compared with high education) were very similar in terms of age and gender, they more often had diabetes, hypertension, or peripheral arterial disease which might complicate their management. However, according to the factor analysis, the differences in target level achievement were only weakly associated with education level. Compared with low level education, mid level education had slightly reduced odds of achieving good risk factor control, and high level education did not change the odds significantly.

Previous research has covered all three phases of cardiac rehabilitation (referral stage, participation stage, long-term behavioral change stage), while particularly focusing on perceived or actual physician-related or patient-related barriers to inclusion of eligible patients in outpatient[12] or inpatient cardiac rehabilitation programs.[13] A comprehensive review was published by Jackson et al for 32 studies with 12,804 patients,[8] differentiated by cardiac rehabilitation phase. Patients were more likely to participate in cardiac rehabilitation programs when they were actively referred (physician's endorsement of the effectiveness of such a program), educated, married, showed high self-efficacy, and when the programs were easily accessible. Patients were less likely to participate when they had to travel long distances to participate in a cardiac rehabilitation program, or experienced guilt over family obligations. Women were less often referred and participated less often, even after referral. Interestingly, in seven of 11 studies, high education was a positive predictor of participation.[14–20] No studies were available for the participation stage itself, and only six pertinent articles with no clear positive or negative predictor variables have been found for the long-term phase.[8]

Our analysis adds to the knowledge of the cardiac rehabilitation participation phase, and unlike other studies, it describes (surrogate) outcomes rather than adherence. Male gender was the strongest factor and was associated with a 38% increase in good control. Female gender was consistently described as a negative predictor for referral in three studies, for participation in 13 studies, and for long-term behavioral change in one study (no positive predictor in any study).[8] The other factors that we found to be negatively associated with good control were increasing age, peripheral arterial disease (a marker for high cardiovascular risk as noted in many studies[21,22]), and a high body mass index (≥ 30 kg/m^2). Generally, the effect sizes (ie, difference of the odds ratios from 1) were very small for education, so the effect of this factor can be considered to be negligible.

Some other findings in this registry deserve consideration. Because guidelines for cardiovascular disease usually focus on conditions, such as coronary heart disease or diabetes, rather than on specific settings, only few treatment goals have been specifically developed for cardiac rehabilitation.[23] Thus, the target values for individual risk factors, such as lipids,[24] blood pressure,[25] and blood glucose,[26] and the medication recommendations for patients with coronary heart disease do not generally differ in the cardiac rehabilitation setting from those for patients managed by family physicians. Drug treatment in cardiac rehabilitation appears to have been intensified in terms of drug classes, drugs, and doses compared with previous years.[10] For example, the proportion of patients treated with beta-blockers and angiotensin-converting enzyme inhibitors/angiotensin receptor blockers was higher compared with previous surveys in the same setting, while the proportion of patients treated with statins and aspirin

was stable. Further, modified treatment approaches (eg, combination therapy of cholesterol absorption inhibitors and statins) and comprehensive patient management[27] seem to have contributed to higher control rates, eg, for cholesterol and its fractions.

However, when discharged from cardiac rehabilitation, many patients still do not meet the targets of the respective guidelines. Similar findings on suboptimal control of lipids,[28,29] diabetes mellitus,[30] and hypertension[31] have been reported in primary care, which is the setting in which most patients with coronary heart disease are managed after cardiac rehabilitation. Reasons may include the limited time period in which physicians have to initiate lifestyle modifications or drug treatment during rehabilitation (about 3–4 weeks). Further possible explanations include the complexity of patients with coronary heart disease who often have concomitant diseases,[32] suboptimal compliance with therapy, or the clinical inertia of the treating physicians.[33,34]

Some methodological aspects deserve consideration. A strength of using the registry was the consecutive inclusion of unselected patients representative of routine clinical care with close follow-up, resulting in a small number of missing values. In terms of limitations, selection bias may have occurred, because centers participating voluntarily in a registry are more likely to have an interest and probably increased knowledge of the research question. Overall, data quality in a registry is not as high as in a study under Good Clinical Practice rules, and audits with source data verification were performed in a limited number of centers only. With regard to education, categories were relatively crude, given that high education comprised a wide spectrum and variation of years at school or university. Owing to the post-hoc approach, we did not have data on certain characteristics reported in other analyses.

Conclusion

The present analysis provides an overview of the characteristics, treatment, and risk factor control in the cardiac rehabilitation setting in Germany. Patients treated in cardiac rehabilitation with different levels of education did not differ relevantly in demographics, but did differ in some clinical aspects. Nonetheless, similar control rates could be achieved for low versus high education level. Thus, with respect to the ultimate goal of cardiac rehabilitation, ie, optimal control of risk factors, education background does not seem to have an important role. However, control of cardiovascular risk factors is not yet adequate and should be improved in the future.

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