



Does outpatient cardiac rehabilitation help patients with acute myocardial infarction quit smoking?

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ABSTRACT

Outpatient cardiac rehabilitation (OCR) reinforces patients' efforts to quit smoking, but the association between participation in OCR and long-term smoking status after acute myocardial infarction (AMI) is unknown. We studied hospitalized smokers with confirmed AMI from two multicenter prospective registries (PREMIER, from January 1, 2003, to June 28, 2004, and TRIUMPH, from April 11, 2005, to December 31, 2008) to describe the association of OCR participation with smoking cessation. Eligible patients smoked at least 1 cigarette per day on average in the 30 days prior to enrollment and completed 12-month follow-up (N = 1307). Structured interviews were completed on subjects at baseline and during follow-up. OCR participation and abstinence from smoking within the prior 30-days (30-day point prevalence abstinence, PPA) were self-reported. We constructed a propensity model of OCR participation based on 22 baseline sociodemographic and clinical characteristics, and constructed hierarchical modified Poisson regression models of 30-day PPA at 12 months after matching on the propensity for OCR participation (with clinical site treated as a random effect). Seventy-four percent of subjects were referred to OCR at hospital discharge, but only 36% participated during follow-up. At 12-month follow-up, 30-day PPA was 57% in OCR participants, compared to 41% in matched OCR non-participants. Participation in OCR was a significant predictor of 30-day PPA at 12 months (adjusted RR 1.38, 95% CI 1.20–1.57). In conclusion, smokers who participated in OCR were significantly more likely to abstain from smoking 12 months after AMI hospitalization.

Cardiac rehabilitation is an evidence-based strategy to decrease morbidity and mortality after acute myocardial infarction (AMI) through exercise, counseling on cardiovascular risk factors, patient education to improve symptom recognition, and psychosocial support during treatment (Balady et al., 2011). A recent meta-analysis of randomized controlled trials showed that participation in exercise-based cardiac rehabilitation significantly reduces cardiovascular mortality (relative risk 0.74, 95% CI 0.64 to 0.86) and the risk of hospital admissions (relative risk 0.82, 95% CI 0.70 to 0.96) in patients with ischemic heart disease (IHD) (Anderson et al., 2016).

Smoking cessation is a cornerstone of secondary prevention among smokers, as it reduces adverse cardiac events through several potential mechanisms: decreased platelet aggregation and thrombus formation,

increased oxygen delivery, decreased catecholamine release and coronary vasoconstriction, reduced oxidative stress and vascular inflammation, and decreased myocardial workload (Benowitz and Gourlay, 1997). Approximately one-quarter of deaths prevented by outpatient cardiac rehabilitation (OCR) have been attributed to smoking cessation (Taylor et al., 2006). Although OCR provides reinforcement for patients in their efforts to quit smoking, there are few empiric data on the association between OCR participation and long-term smoking cessation. Prior studies of smoking behavior in hospitalized smokers with acute coronary syndrome (ACS, which includes AMI and unstable angina) have focused on the effects of discharge recommendations for OCR (Dawood et al., 2008), have been limited to short-term cessation outcomes (< 6 months) (Attebring et al., 2004), or

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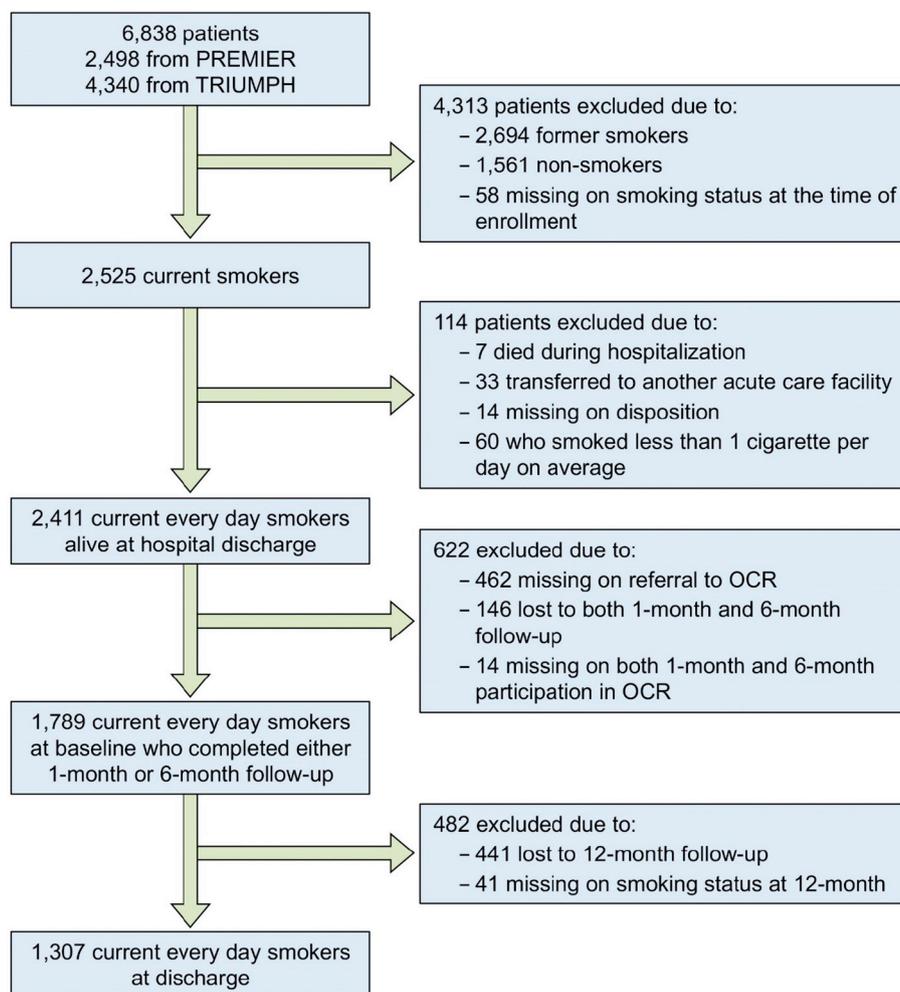
did not examine cardiac rehabilitation as a potential predictor of abstinence (van Berkel et al., 2000; Quist-Paulsen et al., 2005; Holtrop et al., 2009; Gerber et al., 2011; Berndt et al., 2012). Moreover, the relationship between participation in OCR and smoking cessation outcomes might be explained by selection bias (i.e., patients who participate in OCR may be more health conscious than those who do not participate) (Gaalema et al., 2017). This study aims to extend prior research on the effects of OCR referral (Dawood et al., 2008) by examining the association between participation in OCR and smoking status in two large cohorts of patients with biochemically confirmed acute myocardial infarction, using propensity score matching to account for potential selection biases introduced by measured patient characteristics. These data have the potential to further illuminate the benefits of OCR and the need to better support patient participation in such programs.

1. Methods

This study examined patients enrolled in two US multicenter, prospective, observational registries with similar study protocols. The Prospective Registry Evaluating Outcomes after Myocardial Infarction: Events and Recovery (PREMIER) Quality Improvement Registry enrolled patients (N = 2498) at 19 clinical centers from January 1, 2003 to June 28, 2004 (Spertus et al., 2006). Similarly, the Translational Research Investigating Underlying Disparities in Acute Myocardial

Infarction Health Status (TRIUMPH) study enrolled patients (N = 4340) at 24 clinical centers from April 11, 2005 to December 31, 2008 (Arnold et al., 2011). Patients in both registries were at least 18 years of age, with elevated cardiac biomarkers (troponin or creatine kinase-MB fraction assessed within 24 h of admission) and supporting evidence of AMI (electrocardiographic [EKG] ST-segment changes or prolonged ischemic symptoms/signs). Participants were required to either present to the enrolling institution or to have been transferred within 24 h of original presentation, so that the primary clinical decision-making occurred at the enrolling center; patients with elevated cardiac biomarkers resulting from an elective coronary revascularization were excluded. The primary analysis was limited to 1307 patients who survived the initial hospitalization, who reported having smoked cigarettes at least once within 30 days prior to enrollment, and who smoked at least 1 cigarette per day on average (current every day smokers)(Fig. 1). All patients signed an informed consent approved by the participating institution and institutional review board approval was obtained at each participating center.

Data were collected on two groups of variables: 1) factors that may be associated with participation in OCR, and 2) factors associated with continued smoking following a cardiac event. Specifically, trained data collectors performed detailed baseline chart abstraction to document patients' medical history and cardiovascular risk factors (e.g., hypertension, hyperlipidemia, diabetes, chronic heart failure, chronic lung disease), prior revascularization, MI severity (ST-segment



* OCR = outpatient cardiac rehabilitation

Fig. 1. Study flow diagram*.

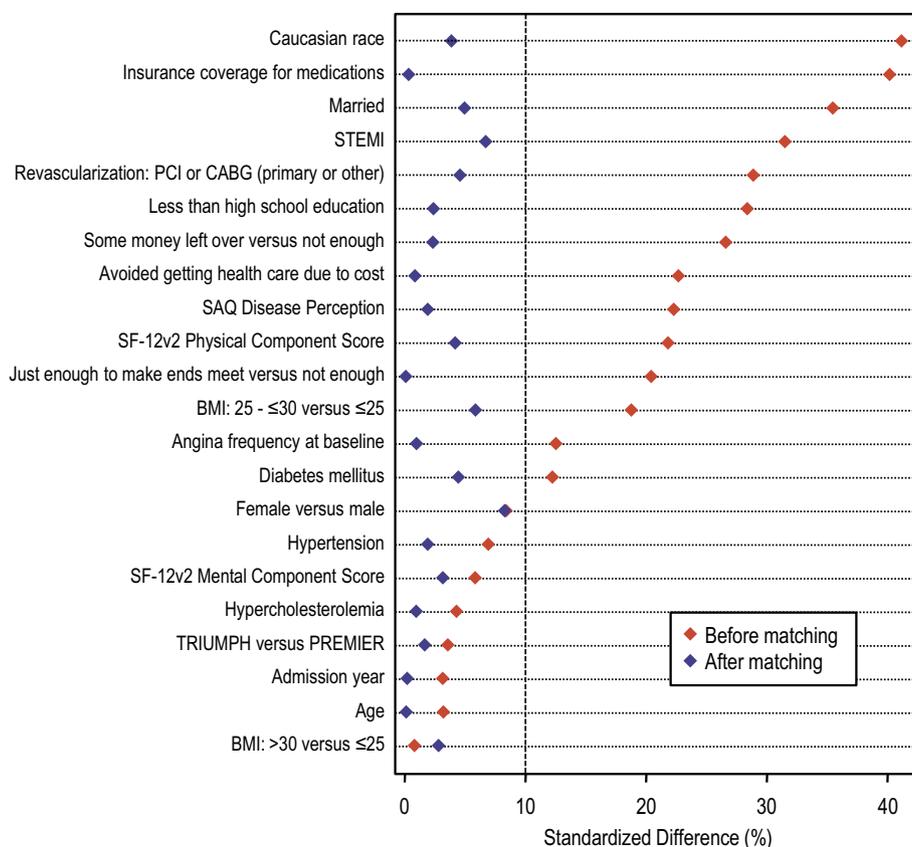


Fig. 2. Standardized difference in covariate means or proportions between comparison groups at 12-month follow-up, before and after propensity score matching.

elevation MI [STEMI] vs non-ST-segment elevation MI (Motivala et al., 2011), inpatient care and treatments (in-hospital revascularization, prescription of aspirin, β-blocker, statin, angiotensin-converting enzyme inhibitor, or angiotensin receptor blocker), and laboratory results. We also collected data on body mass index (BMI, based on first height and weight in medical record), which was categorized as: < 25 (normal), 25 to < 30 (overweight), and > 30 kg/m² (obese). Prescription of first-line smoking cessation medications (nicotine patch, gum, lozenge, inhaler, or nasal spray; bupropion; varenicline) at discharge was also abstracted from the medical record.

During hospitalization, each patient underwent a standardized interview by research staff to document sociodemographic and economic variables (age, sex, self-identified race, marital status, education, insurance coverage, and financial status),(Dawood et al., 2008; Gerber et al., 2011; Berndt et al., 2012; Tzou et al., 2004; Friedman et al., 1997) smoking-related variables (cigarette intake, age at smoking initiation, counseling by staff on smoking cessation),(van Berkel et al., 2000; Quist-Paulsen et al., 2005; Gerber et al., 2011) psychosocial variables (depression, social support, perceived stress, current alcohol use),(Berndt et al., 2012; Perez et al., 2008; Pogosova et al., 2015) and self-reported health status(Cupples et al., 2010). Follow-up interviews were conducted at one, six, and 12 months by a centralized, highly experienced, follow-up center.

Measures of health status at baseline and follow-up included the Seattle Angina Questionnaire (angina frequency, quality of life) (Spertus et al., 1995), and the Physical and Mental Health components of the Short-Form 12 (SF-12), version 2 (Ware et al., 2008). We also asked participants if they avoided getting health care due to cost and if they had insurance coverage for prescription drugs. An additional measure of financial burden was based on monthly budget, with responses of “some money left over,” “just enough to make ends meet,” or “not enough to make ends meet” (Rahimi et al., 2007). Depressive symptoms were quantified with the 9-item Patient Health

Questionnaire (PHQ-9); a PHQ-9 score > 10 indicates a high probability of clinical depression (Kroenke et al., 2001). Social support was measured with the Enhancing Recovery in Coronary Heart Disease (ENRICH) social support inventory (Mitchell et al., 2003). To assess psychological stress, we used a 4-item version of the Perceived Stress Scale (PSS); changes in the PSS are predictive of changes in smoking rate (Cohen et al., 1983). Current alcohol use was defined as having at least 1 drink per month. During follow-up, participants were asked about total outpatient clinic visits since the prior interview (measure of health seeking behavior).

The primary independent variable of interest was participation in OCR, which was assessed at the 1- and 6-month follow-up interviews. Specifically, patients were asked if they had been referred to OCR and, if so, whether or not they had participated in a cardiac rehabilitation program since hospitalization for their “heart attack or heart problem.” In the analysis of 1- and 12-month cessation outcomes, those who confirmed that they had participated in at least 1 session within 1 month and within 6 months of hospital discharge were defined as OCR participants, respectively. Referral to OCR was determined by the presence of an order for cardiac rehabilitation at discharge in the medical record. Cardiac rehabilitation programs at all study sites were institution-based at the time of this study.

Smoking status was systematically collected at each follow-up interview. Patients who responded affirmatively to the following question were considered current smokers: “I have smoked (even a puff) in the past 30 days.” The primary outcome was 30-day point prevalence abstinence (PPA) at 12-month follow-up, which is associated more closely with lifelong cessation than assessments at 6-month follow-up (Hughes et al., 2003); 30-day PPA also allows comparison with other recent studies of hospitalized smokers (Riley et al., 2012). Smoking-related characteristics included cigarettes per day (< 10, 11–20, > 20), age of first regular cigarette smoking (in tertiles of < 15 years, 15 to 17 years, and 18 years or older), in-hospital receipt of smoking cessation counseling, and

prescription of cessation medication at discharge.

Baseline characteristics of OCR participants and nonparticipants were compared using the two-independent-sample *t*-test, Wilcoxon rank-sum, or chi-square tests as appropriate for the type of data. As the primary outcome of interest (30-day PPA) was anticipated to be a common occurrence, we used a modified Poisson regression model with robust variance estimates in the main analysis. (Zou, 2004) As selection bias may confound the relationship between the exposure of interest and outcome, we developed a propensity model for OCR participation during the 6 months after hospital discharge, based on baseline data available at the time of

initial hospital discharge (see Fig. 2 for list of explanatory variables in the propensity model) (D'Agostino, 1998). We selected a set of variables common to both registries that could potentially influence the decision to refer to OCR (shown in Fig. 2), based on prior literature and expert opinion (Gaalema et al., 2015; Beswick et al., 2004; Fang et al., 2017; Grace et al., 2008; Clark et al., 2012). Model discrimination was assessed by the *c*-statistic (which is equivalent to the area under the receiver operating characteristic curve) (Hanley and McNeil, 1983) and model calibration was evaluated with the Hosmer-Lemeshow goodness of fit test (Hosmer and Lemeshow, 2000).

Table 1

Baseline characteristics of participants and non-participants in outpatient cardiac rehabilitation (OCR).

	Participants (N = 475)	Non-participants (N = 832)	P-value
Sociodemographics			
Age, mean (sd)	54.6 (10.1)	54.9 (9.9)	0.58
Sex, % male	70.3	66.5	0.15
Race category, %			< 0.001
White/Caucasian	84.0	66.7	
Black/African American	12.0	27.1	
Other	4.0	6.1	
Less than high school education, %	44.3	58.3	< 0.001
Marital status, % married	64.2	46.9	< 0.001
Insurance coverage for medications, %	81.4	63.8	< 0.001
Monthly financial situation, %			< 0.001
Some money left over	55.2	34.2	
Just enough to make ends meet	27.8	40.3	
Not enough to make ends meet	17.0	25.5	
Avoided getting health care due to cost, %	23.6	33.7	< 0.001
Study registry, %			0.52
PREMIER	42.3	40.5	
TRIUMPH	57.7	59.5	
MI characteristics and self-reported health			
Final study diagnosis, %			< 0.001
ST-elevation myocardial infarction	65.5	50.1	
Non-ST-elevation myocardial infarction	34.5	49.9	
Revascularization: PCI or CABG, %	88.8	78.2	< 0.001
SAQ quality of life, mean (sd)	66.2 (22.7)	61.0 (24.0)	< 0.001
SF-12v2 physical component score, mean (sd)	45.3 (11.8)	42.5 (12.1)	< 0.001
SF-12v2 mental component score, mean (sd)	49.0 (11.9)	48.2 (11.8)	0.29
Angina frequency at baseline, %			0.03
Good	53.6	47.3	
Mild/moderate/severe	46.4	52.7	
Smoking-related factors			
Cigarettes per day, %			0.18
1 to 10	30.5	36.4	
11 to 20	40.4	37.1	
> 20	29.0	26.4	
Age started smoking regularly, %			0.06
Tertile 1 (0 to < 15)	26.1	30.7	
Tertile 2 (15 to < 18)	27.8	29.8	
Tertile 3 (18 to 75)	46.0	39.5	
Patient instructions: smoking cessation, %	83.8	73.6	< 0.001
Cessation medication prescribed at discharge, % ^a	13.3	11.1	0.23
Other cardiovascular risk factors			
Diabetes mellitus, %	16.4	21.3	0.03
Hypertension, %	52.8	56.4	0.22
Hypercholesterolemia, %	44.8	42.7	0.45
Body Mass Index category, %			< 0.001
Normal weight (BMI < 25)	18.8	27.4	
Overweight (BMI 25 – < 30)	42.8	33.7	
Obese (BMI ≥ 30)	38.4	39.0	
Psychosocial factors			
ENRICH social support score, mean (sd)	21.9 (4.3)	21.3 (4.8)	0.02
Alcohol use greater than monthly, %	31.4	33.9	0.37
PHQ-9 depression score, mean (sd)	5.3 (5.3)	6.0 (5.5)	0.03
Treatment-related factors			
Average number of outpatient clinic visits per month, median (IQR)	0.50 (0.33, 0.67)	0.42 (0.25, 0.67)	0.02

Abbreviations: MI = Myocardial Infarction; PCI = Percutaneous coronary intervention; CABG = Coronary artery bypass graft; SF-12 = Short Form, 12 question, version 2; SAQ = Seattle Angina Questionnaire; SD = Standard deviation; IQR = Interquartile range.

^a Only FDA-approved medications for smoking cessation were included (nicotine patch, gum, lozenge, inhaler, or nasal spray; bupropion; varenicline).

We then performed a matched analysis in which each OCR participant was matched by propensity score to an OCR non-participant. Only those matches that were within 0.2 SD of the logit of the propensity score were included (Rosenbaum and Rubin, 1985); once a match was identified, we removed the matched pair from the sample and then repeated the process. We checked for balance of covariates by calculating the standardized difference in covariate means between patients within matched strata - small absolute values of the standardized difference ($< 10\%$) support the assumption of balance between comparison groups in measured characteristics. The relative risk (RR) for OCR participation on PPA was calculated at twelve months (Ockene et al., 2000); clinical site was modeled as a random effect. Smoking-related factors, psychosocial factors (PHQ-9, social support, PSS, current alcohol use), and number of outpatient clinic visits were then added sequentially to these models to assess whether they attenuated the association between OCR participation and cessation outcomes. To evaluate the association between OCR participation and smoking status during the entire 12-month follow-up period, we also conducted a repeated-measures analysis of PPA (at 1, 6, and 12 months) using time-dependent propensity scores and generalized estimating equations (GEE) (Gerber et al., 2011) to calculate odds ratios and 95% confidence intervals.

We assessed the sensitivity of our results to assumptions regarding missing follow-up data. In the main analysis, patients who died or were lost to follow-up at 12 months were excluded (i.e., complete case analysis, $N = 1307$). We performed an analysis using inversely-weighted propensity scores, which represents the probability of each participant having available data at 12-month follow-up ($N = 1789$, including those who were lost to follow-up or were missing smoking status at 12-months); this approach more heavily weights the values of those subjects most likely to have missing follow-up data (Lunceford and Davidian, 2004). We also repeated the analysis using penalized imputation ($N = 1789$), which assumes that subjects who are lost to follow-up are still smoking at 12 months (subjects who died during 12-month follow-up were excluded in this analysis).

2. Results

An overview of the study sample is shown in Fig. 1. Of 6838 AMI patients in both registries, 2525 (37%) were current smokers at the time of their AMI. Of 2411 smokers who were alive at discharge, 1307 completed follow-up (54%) and 1104 subjects were excluded because they were missing data on OCR referral or participation ($N = 476$), were lost to follow-up ($N = 587$), or were missing data on smoking status at 12-month follow-up ($N = 41$). The mean age of the analysis sample was 54.8 years, 68% were male, and 73% were White/Caucasian. At baseline, 34, 38, and 27% of subjects were light (≤ 10 cigarettes per day, cpd), medium (11–20 cpd), and heavy (> 20 cpd) smokers, respectively.

Seventy-four percent of subjects were referred to OCR at the time of discharge and 475 (36% of total) reported any participation during the 6 months following MI hospitalization. In bivariate analyses, OCR participants were significantly more likely to have had an ST-elevation MI and to have received revascularization during the index hospitalization ($p < 0.001$ for both; Table 1). Despite having more severe ischemic heart disease at presentation, OCR participants had a better health outlook (based on the SAQ Quality of Life subscale), better physical function (SF-12), fewer depressive symptoms (PHQ-9), and greater social support (based on the ENRICH score) at baseline. With regard to tobacco treatment, instructions for smoking cessation were more likely to have been documented in OCR participants, but prescription of smoking cessation medications at discharge was similar in both groups.

Propensity score models for OCR participation at 12-month follow-up (based on sociodemographic variables, cardiovascular risk factors, AMI characteristics, and self-reported health) showed good

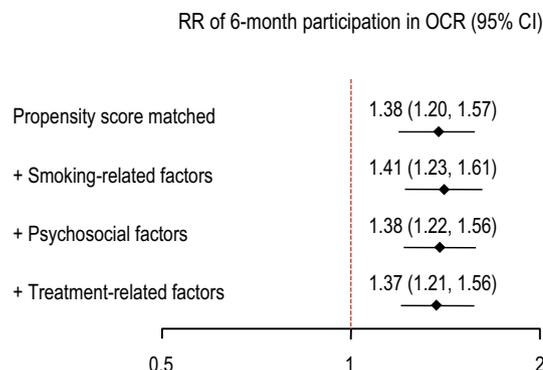


Fig. 3. Association between participation in OCR and point-prevalence abstinence (PPA). OCR = outpatient cardiac rehabilitation; RR = relative risk, CI = confidence interval.

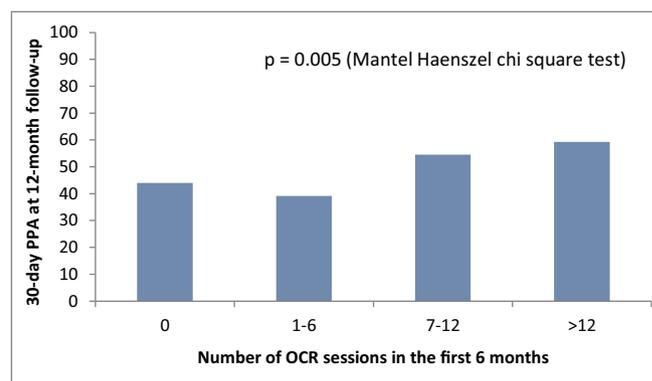


Fig. 4. Dose-response relationship between OCR attendance and point-prevalence abstinence (PPA) in the PREMIER registry. (TRIUMPH participants were not included, as the number of OCR sessions for these patients was only assessed through 1-month follow-up). OCR = outpatient cardiac rehabilitation.

discrimination (C-statistic = 0.77). After optimal matching, comparison of OCR participants and non-participants showed standardized differences of $< 10\%$ across all model covariates (Fig. 2). These analyses (in which all candidate variables were forced into multivariable models) showed that low educational attainment, financial hardship, and lack of health insurance were associated with OCR non-participation, whereas patients with STEMI and those who were overweight (BMI 25–30 kg/m²) were more likely to participate.

The unadjusted 30-day PPA for OCR participants and non-participants was 57% and 41% at 12-month follow-up, respectively ($p < 0.001$). After propensity score matching ($N = 1255$), the estimated relative risk (RR) of 30-day PPA for OCR participation was 1.38 (95% CI 1.20–1.57). This estimate changed minimally after adjustment for smoking-related variables, psychosocial factors, and outpatient visit rates: RR = 1.37, 95% CI = 1.21–1.56 (Fig. 3). Repeated measures analysis with time-dependent covariates showed a somewhat attenuated, but still significant, treatment effect (RR = 1.22, 95% CI 1.11–1.33). In an unadjusted analysis of PREMIER subjects with complete data on OCR attendance during 6-month follow-up, there was a significant trend toward greater 30-day PPA as the number of OCR sessions increased (Fig. 4).

Sensitivity analyses demonstrated that the original results were robust across different methods for handling missing data. Patients with missing smoking status at 12-month follow-up were significantly younger, were more likely to be non-white, have less than a high school education, to avoid getting healthcare due to cost, and to be treated without revascularization; they also had lower social support and worse SF-12 physical and mental health. In an analysis of 12-month survivors, using inversely weighted propensity scores ($N = 1892$), the fully

adjusted relative risk was unchanged: RR = 1.37, 95% CI = 1.21–1.56). Using penalized imputation, the estimated RR for 30-day PPA was somewhat larger (fully adjusted RR = 1.66, 95% CI = 1.47–1.86).

3. Discussion

Engaging AMI patients who smoke to quit tobacco is a critically important secondary prevention goal. In this large study of smokers recovering from an AMI, we found that participation in OCR was associated with an increased likelihood of smoking cessation during short- and long-term follow-up, after accounting for potential selection bias using propensity score matching. Although hospitalization is a teachable moment for smoking cessation (McBride et al., 2003; Boudreaux et al., 2012), 40–69% of patients with ACS resume smoking, despite the known risks for recurrent coronary events (Attebring et al., 2004; Holtrop et al., 2009; Eisenberg et al., 2016; Minneboo et al., 2017), and most patients who quit relapse within the first few weeks following hospital discharge (Colivicchi et al., 2011). Through its focus on exercise and heart-healthy lifestyle, participation in OCR can reinforce patients' efforts to maintain abstinence from smoking after hospital discharge. There remains a large gap between evidence and practice, however; although most of the patients (74%) in this study were referred to OCR, only 36% attended 1 or more sessions during follow-up.

This study extends the results of an earlier analysis of data from the PREMIER registry, which showed that the odds of smoking cessation were significantly greater among those receiving discharge recommendations for cardiac rehabilitation (OR = 1.80, 95% confidence interval = 1.17–2.75) (Dawood et al., 2008). We found that the absolute risk reduction associated with actual OCR participation in the current study was 17% in multivariable models, which is smaller than the effect observed for being merely referred to OCR (Dawood et al., 2008). Our findings also confirm the results of Attebring et al., who found that non-participation in cardiac rehabilitation was an independent predictor of continued smoking at 3-month follow-up in patients hospitalized with ACS at a university hospital in Sweden (Attebring et al., 2004). The authors suggested two possible interpretations for this finding: that more patients who had stopped smoking had chosen to participate in OCR or that OCR itself had a positive influence on smoking cessation.

Negative attitudes toward smoking cessation, nicotine dependence, low self-efficacy, and negative social influences reduce the likelihood of long-term abstinence from smoking in AMI patients (van Berkel et al., 2000; Quist-Paulsen et al., 2005). Moreover, AMI patients frequently report symptoms of depression, and depressed smokers who attempt to quit are more likely to relapse (Dawood et al., 2008; McGee et al., 2006), in part because of strong nicotine withdrawal symptoms (Thorndike et al., 2008). OCR may improve cessation outcomes by strengthening motivation to quit, building perceptions of smoking self-efficacy, providing social support during treatment, and capitalizing on potential synergies with other cardiovascular risk behaviors (Gordon et al., 2001; Doherty et al., 1998). An example of the latter is the finding that increasing physical activity during OCR may have positive impacts on both depressive symptoms and smoking cessation (Ussher et al., 2012).

The overall proportion of patients who reported any OCR participation in the current study (36%) is comparable to that reported in the 2005 Behavioral Risk Factor Surveillance System survey (34.7%) (Centers for Disease Control and Prevention, 2008). Compared with nonsmokers, smokers who are hospitalized for IHD-related events are less likely to enroll in OCR (Tzou et al., 2004; Gaalema et al., 2015) and those who continue to smoke after hospital discharge are more likely to drop out of OCR (Attebring et al., 2004). We identified several correlates of OCR participation that have been previously reported in other studies, including age (Cupples et al., 2010; Beswick et al., 2004), low

educational attainment (Fang et al., 2017), lack of insurance (Fang et al., 2017), financial constraints (Grace et al., 2008; Clark et al., 2012), depression (Pogosova et al., 2015), and social support (Grace et al., 2008; Clark et al., 2012). Reasons for not attending center-based OCR may also involve multiple logistical and contextual factors, such as competing work and family obligations, lack of transportation, and the accessibility of rehabilitation program sites and timing of sessions (Savage et al., 2011; Karmali et al., 2014).

Our results should be interpreted in the context of the following limitations. First, the use of observational data is always subject to unmeasured confounding. Although we attempted to minimize confounding on account of selection bias through the use of propensity scores, there are potentially other unmeasured factors, such as personality types, social influences, and treatment adherence factors, that were not included in our model and may have been related both to OCR participation and smoking cessation. Such confounding would suggest that OCR participation is merely a marker of patients' readiness to quit. Second, OCR participation was based on participant self-report; however, agreement between self-reported and program-reported rates of OCR participation has been shown to be quite high. In one prospective study of cardiac rehabilitation, participants self-reported attending a mean of 81.8% (sd = 25.8%) of prescribed OCR sessions by self-report, with OCR sites reporting that participants completed 80.8% (sd = 31.3%) of sessions ($r = 0.66$) (Kayaniyil et al., 2009). Third, we did not capture the type, intensity, frequency, and length of OCR participation and cannot determine whether there is a dose-response association between OCR participation and smoking cessation (Kureshi et al., 2016). Similarly, we were unable to determine the specific components or attributes of OCR that were associated with improved cessation outcomes. Cardiac rehabilitation is a complex intervention that often incorporates several therapies, including exercise training, education for heart-healthy living and behavior change, stress management, psychological support, and strategies that target traditional risk factors for cardiovascular disease (including smoking cessation) (Anderson et al., 2016; Savage et al., 2011). Fourth, we did not have data on level of nicotine dependence and confidence in quitting, which have been associated with long-term smoking cessation (Quist-Paulsen et al., 2005). Fifth, varenicline (which was approved by the FDA in May 2006) was not available during the entire study period (2003–2008). Our findings should be confirmed in a contemporary cohort of patients with AMI. Finally, it was not feasible to obtain biochemical confirmation of smoking status during follow-up. Although a small minority of patients with ACS may misreport abstinence (Attebring et al., 2004), we would not expect the rate of misreporting to differ based on OCR participation status. Moreover, self-reported abstinence is more likely to be accurate in observational studies without specific smoking cessation interventions and in the absence of strong incentives to deceive (Velicer et al., 1992; SRNT Subcommittee, 2002).

Despite these limitations, our findings have potential implications for the clinical care of smokers with AMI. In addition to referring these patients to OCR, clinicians should actively encourage current smokers to participate on an ongoing basis, which may substantially improve cessation outcomes (Wallentin et al., 2014). Patients who perceive that their physician considers OCR to be important are more likely to participate (McCorry et al., 2009). The Center for Medicare & Medicaid Services (CMS) should also revisit policies and incentive payments that aim to reduce barriers to patient participation in OCR (Centers for Medicare and Medicaid Services, 2017). Moreover, cardiac rehabilitation specialists need to be well versed in motivational interviewing, which has been shown to increase quit rates (Lindson-Hawley et al., 2015), and should look for natural synergies between smoking cessation and other cardiovascular risk behaviors (especially exercise and diet). Eligible AMI patients should also be routinely offered pharmacotherapy for smoking cessation (Katz et al., 2011; Rigotti et al., 2012) and all FDA-approved medications should be covered by health insurance plans, as recommended by the US Public Health Service guideline (and

required by the 2010 Affordable Care Act) (Fiore et al., 2008; Centers for Disease Control and Prevention, 2012). More recently, varenicline has been shown to attenuate nicotine withdrawal symptoms during smoking abstinence and improve long-term cessation rates in patients with ACS (Eisenberg et al., 2016).

4. Conclusions

In this observational study, cigarette smokers who participate in OCR after an AMI are more likely to self-report abstinence from smoking at 12-month follow-up compared to propensity-matched smokers who do not participate in CR. Strengths of this study are its prospective design, large effective sample size, and the use of propensity-score matching to account for selection bias (related to OCR participation). Limitations of this analysis include the possibility of residual confounding, the assessment of smoking status and OCR participation by self-report, and the lack of information on the quality of OCR-related cessation interventions. Future studies should better characterize the frequency, intensity, and duration of OCR and the specific elements that were delivered in order to determine possible causal mechanisms that could explain the association between OCR participation and smoking cessation. Novel strategies to improve OCR participation and to integrate state-of-the-art tobacco treatment into OCR programs should be evaluated in randomized clinical trials or controlled quasi-experimental trials.

Conflict of interest

The authors declare that there is no conflict of interest.

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