

# Improving cardiac rehabilitation referral rates in patients with coronary heart disease from diverse communities using an electronic order system

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Received date: March 07, 2024

Accepted date: June 24, 2024

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## Abstract

**Background:** Despite the benefits of cardiac rehabilitation (CR), local and national CR referral and participation rates remain low when compared to established cardiovascular therapies especially amongst racial/ethnic groups.

**Objectives:** This study investigated the effects of the implementation of a CR program and electronic order set (EOS) in a large health system on CR referral and participation rates among a diverse group of patients with coronary heart disease (CHD).

**Methods:** A total of 360 patients from UCSD Health who presented with ACS were prospectively evaluated during initial hospitalization and 6- and 12-weeks post-discharge. Multivariable logistic regression model assessed referral and participation rates by week-1 and -12 post-discharge, adjusting for gender, age, race, ethnicity, geography, and referring physician subspecialty.

**Results:** UCSD CR program implementation led referral rates to increase at week-1 (Pre- 38.6% and Post- 54.9%,  $p = 0.003$ ) and week-12 (Pre- 54.1% and Post- 59.8%,  $p = 0.386$ ). Post-CR referrals were more likely at week-1 (OR: 1.93, 95% CI 1.27-2.95) and week-12 (OR: 1.26, 95% CI 0.79-2.00). EOS implementation increased referral rates at week-1 (Pre- 40.3% and Post- 58.7%,  $p < 0.001$ ) and week-12 (Pre- 54.9% and Post- 60.4%,  $p = 0.394$ ) with referrals more likely at week-1 (OR: 2.1, 95% CI 1.35-3.29) and week-12 (OR: 1.25, 95% CI 0.795-1.98). Participation in CR following EOS was more likely at both week-1 and week-12. Multivariable analysis revealed disparities in referral based on race, geographic location, and referring physician subspecialty.

**Conclusion:** A CR program and EOS implementation were shown to increase referral rates with long-term potential for increasing referral and participation rates.

**Condensed Abstract:** This prospective study investigated the implementation of a cardiac rehabilitation (CR) program and electronic order set (EOS) within the same health system on CR referral and participation rates. 360 patients with ACS were evaluated over a period of 12 weeks. UCSD CR program and EOS implementation led referral rates to increase at week-1 and -12. CR participation was more likely to increase at week-1 and -12 following EOS. Multivariable analysis revealed disparities in referrals disproportionately affecting racial and ethnic minority groups and rural communities. CR and EOS implementation may increase CR referral rates for diverse patients with CHD.

**Keywords:** Coronary heart disease, Cardiac rehabilitation, Electronic order set, Disparities, Race and Ethnicity

**Abbreviations:** EOS: Electronic Order Set; CR: Cardiac Rehabilitation; PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; MI: Myocardial Infarction; LVEF: Left Ventricular Ejection Fraction; COPD: Chronic Obstructive Pulmonary Disease; OR: Odds Ratio; CI: Confidence Interval; ACS: Acute Coronary Syndrome; CHD: Coronary Heart Disease

**Background**

Cardiac Rehabilitation (CR) is a medically supervised preventative cardiovascular program that involves a multi-disciplinary approach including physician-prescribed exercises, cardiac risk factor modification (education, counseling, and behavioral intervention), psycho-social assessment, outcomes assessment, and individual treatment plans [1,2]. It is recommended for both inpatient and outpatient settings following cardiovascular illnesses including myocardial infarction (MI), percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), and for those with documented chronic stable angina [2].

The benefits of CR are well-studied and participation is considered a Class Ia recommendation by the American Heart Association (AHA) and American College of Cardiology (ACC) for patients with coronary heart disease (CHD) including acute MI or coronary revascularization [3,4]. Despite the documented benefits, referral and participation rates are strikingly low. Suaya et al. 2007 [5] found CR utilization ranges from 5.2% to 42% across states, and [6] noted low CR participation rates, ranging from 19% to 34% in national analyses.

The AHA Get with the Guidelines tool [7] is an electronic program designed to facilitate referrals and maximize inpatient quality improvement. This “automatic” referral strategy raises awareness regarding CR eligibility and ensures physicians consider CR as part of the integral process for patient recovery and overall wellness. Availability and use of an Electronic Ordering System (EOS) has been suggested to possibly improve CR utilization [8,9]. Therefore, we set to investigate the effects of the availability of both a local CR program and an EOS on referral and participation rates within a diverse patient population with CHD. We hypothesized that the availability of a local CR program and EOS would positively impact referral and optimally reflect in enrollment and participation rates.

**Methods**

**Study design and population**

Our prospective study included 360 patients hospitalized with ACS to the quaternary hospitals part of UCSD Medical Center and the UCSD Sulpizio Cardiovascular Center. Inclusion criteria included adult patients ≥18 years from rural and urban communities admitted for PCI, CABG, or acute MI who were able to provide written informed consent prior to initiation of the study and who displayed fluency in written English, Spanish, or Chinese. Additional inclusion

criteria included access to a telephone, availability of baseline health status data, and achievement of clinical stability allowing study participation, specifically cardiac rehabilitation. A key factor for selecting patients was enrolling patients within one week of acute coronary event or qualifying cardiac procedure and ensuring ability to ambulate. Exclusion criteria included decompensated congestive heart failure (NYHA III or IV) at the time of enrollment, LVEF ≤ 35% and any of the following comorbid medical conditions; severe COPD, need for additional cardiac revascularization procedure, severe peripheral arterial disease, uncontrolled arrhythmias, stroke within 6 months of enrollment, significant anemia (hemoglobin <9 mg/dL), active drug use and life expectancy less than 1 year.

Hospitalized patients enrolled in the study were asked to answer a survey at time of discharge (week 1) and received follow-up phone calls six and twelve weeks following their discharge to complete additional surveys (Figure 1). CR referral, enrollment, and participation rates were determined based on information provided in patient surveys. For the purpose of this study, week 1 and week 12 surveys were included in the analysis. The 360 enrolled patients were grouped into pre- and post- CR cohorts and pre- and post-EOS cohorts based on discharge date and relation to implementation of both UCSD CR program and EOS.

**Outcomes**

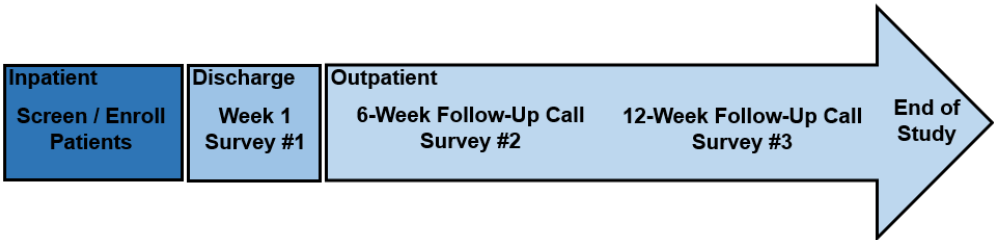
Primary outcomes investigated included referral and participation in CR at different time intervals, week-1 and week-12. Secondary outcomes included the effect of gender, age, race, ethnicity, geography, and subspecialty of referring physician on CR referral and participation rates.

**Geographical stratification**

The 2013 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties [10] was utilized to stratify patients by geographical locations using home zip codes. Classes included large central metro (counties with a population of 1 million or more), large fringe metro (counties of 1 million or more that do not qualify as large central metro), medium metro (counties of 250,000-999,999), and small metro (counties of <250,000).

**Statistical analysis**

Baseline characteristics of the Pre- and Post- patient cohorts were expressed as mean with standard deviation and count with percentage, and were compared by paired t-tests and chi-square analysis for continuous and categorical variable, respectively. The univariable and multivariable logistic regression model was utilized



**Figure 1.** Method flow sheet of enrolling patients, administering survey #1 at week 1, survey #2 at week 6, survey #3 at week 12 of the study, and concluding patient follow up.

to assess the impact of establishing CR program and availability of an EOS on referral and participation at week-1 and week-12. For multivariable logistic regression, potential confounders such as gender, age, race, ethnicity, geography, subspecialty of referring physician, and insurance were adjusted for in the model.

**Results**

**Patient characteristics of CR and EOS cohort**

A total of 360 patients with CHD were enrolled in the study with one patient lost to follow up. The Pre-CR cohort included a total of 184 patients of whom 69.6% were male, with a mean age of 63.6 years, and a racial composition of 58.7% white. The Post-

CR cohort included 175 patients of whom 76.6% were male, with a mean age of 63.2 years and a racial composition of 48.9% white. The Pre-EOS cohort consisted of 240 patients of whom 71.1% were male, with a mean age of 63.3 years and a racial composition of 57.3% white; while the Post-EOS cohort consisted of 120 patients of whom 76.7% were male, with a mean age of 63.8 years and a racial composition of 47.1% white. In regard to ethnic background, Hispanics comprised 39.1% and 49.4% in the Pre-CR and Post CR cohorts respectively. Similarly, Hispanics comprised 40.2% and 52.1% in the Pre-EOS and Post-EOS cohorts respectively. See **Table 1** for additional details regarding demographic representation.

**Table 1** shows Pre-and Post- CR and EOS cohort characteristics.

**Table 1. Demographic characteristics of patients in the following cohorts (Pre-CR, Post-CR, Pre-EOS, and Post-EOS).**

Variable	Pre-CR N=184	Post-CR N=175	P-value	Pre-EOS N=240	Post-EOS N=120	P-value*
<b>Sex</b>						
<b>Female</b>	30.4%	23.4%	0.169	28.9%	23.3%	0.323
<b>Male</b>	69.6%	76.6%		71.1%	76.7%	
<b>Age</b>	63.6	63.2	0.742	63.3	63.8	0.643
<b>Race</b>						
<b>Non-white</b>	41.3%	51.1%	0.078	42.7%	52.9%	0.085
<b>White</b>	58.7%	48.9%		57.3%	47.1%	
<b>Ethnicity</b>						
<b>Hispanic</b>	39.1%	49.4%	0.064	40.2%	52.1%	0.042
<b>Language</b>						
<b>English</b>	71.7%	68.0%	0.511	72.0%	65.8%	0.283
<b>Non-English</b>	28.3%	32.0%		28.0%	34.2%	
<b>Language Read</b>						
<b>English</b>	69.6%	65.5%	0.099	69.9%	63.0%	0.165
<b>Mandarin/Cantonese</b>	0.5%	0.0%		0.4%	0.0%	
<b>Other</b>	2.2%	0.0%		1.7%	0.0%	
<b>Spanish</b>	27.7%	34.5%		28.0%	37.0%	
<b>Language Spoken</b>						
<b>English</b>	69.0%	61.5%	0.244	69.0%	58.0%	0.082
<b>Mandarin/Cantonese</b>	0.5%	0.0%		0.4%	0.0%	
<b>Spanish</b>	28.3%	35.6%		28.9%	37.8%	
<b>Tagalog or Ilocano</b>	0.0%	1.1%		0.0%	1.7%	
<b>Other</b>	2.2%	1.7%		1.7%	2.5%	
<b>City</b>						
<b>Rural</b>	27.7%	27.0%	0.975	26.8%	28.6%	0.816
<b>Urban</b>	72.3%	73.0%		73.2%	71.4%	
<b>Metro</b>						
<b>Large metro</b>	60.4%	53.8%	0.057	59.5%	52.5%	0.330
<b>Medium metro</b>	0.50%	4.00%		1.7%	3.4%	
<b>Small metro</b>	39.0%	42.2%		38.8%	44.1%	

<b>Annual Income</b>						
<15k/yr	23.4%	17.8%	0.282	23.0%	16.0%	0.103
>60k/yr	27.7%	29.3%		27.6%	30.3%	
0-45k/yr	10.3%	6.90%		8.8%	8.4%	
15-30k/yr	13.6%	10.9%		14.6%	7.6%	
45-60k/yr	4.30%	6.90%		5.0%	6.7%	
No disclosure	20.7%	28.2%		20.9%	31.1%	
<b>Insurance Coverage</b>						
HMO	12.0%	16.6%	<0.001***	13.8%	15.0%	<0.001***
Medi-cal/Medicaid	22.3%	22.9%		22.2%	23.3%	
Medicare	11.4%	29.1%		13.0%	34.2%	
Medicare-Medical	17.9%	4.0%)		16.3%	0.8%	
Other	1.6%	5.7%		1.7%	7.5%	
PPO	15.2%	15.4%		13.8%	18.3%	
PPO+Medicare	19.6%	6.3%		19.2%	0.8%	

\*p<0.05 considered statistically significant

**Table 2** shows medical comorbidities found in the Pre- and Post-CR and EOS cohorts.

**Table 3** shows CR referral and participation % in Pre-CR and Post-CR cohorts in weeks 1 and 12.

**Table 4** shows CR referral and participation % in Pre-EOS and Post-EOS cohorts in weeks 1 and 12.

#### Effect of new CR center on referral and participation rates

The availability of a local CR program in the health system prompted referral rate increases notable at both week-1 (38.6% in Pre-CR versus 54.9% Post-CR,  $p = 0.003$ ) and week-12 (54.1% Pre-CR versus 59.8% in Post-CR,  $p = 0.386$ ). Univariate logistic regression analysis revealed patients were more likely to be referred in the Post-CR period; week-1 odd ratio (OR) of 1.93 (95% CI 1.27-

**Table 2. Comorbidities of individual cohorts.**

Variable	Pre-CR N=184	Post-CR N=175	P-value	Pre-EOS N=240	Post-EOS N=120	P-value
<b>Prior CAD</b>	51.1%	36.6%	0.008*	46.0%	40.0%	0.331
<b>CABG</b>	7.1%	5.1%	0.590	7.5%	3.3%	0.183
<b>DES</b>	31.5%	21.1%	0.035*	28.0%	23.3%	0.409
<b>Smoker</b>						
Prior	74.5%	73.7%	0.909	75.3%	71.7%	0.564
Current	40.8%	42.9%		41.8%	41.7%	
<b>DM</b>	45.1%	34.9%	0.061	42.3%	35.8%	0.290
<b>CHF</b>	6.0%	6.3%	1.000	5.9%	6.7%	0.946
<b>Liver Disease</b>	2.7%	4.0%	0.702	3.3%	3.3%	1.000
<b>HTN</b>	82.1%	76.0%	0.199	79.9%	87.5%	0.694
<b>Kidney Disease</b>	12.0%	12.6%	0.987	13.4%	10.0%	0.451
<b>PAD</b>	3.3%	5.1%	0.531	3.8%	5.0%	0.786
<b>Atrial Fibrillation</b>	7.6%	6.9%	0.943	6.3%	9.2%	0.435
<b>CVA</b>	6.0%	6.9%	0.023*	6.3%	6.7%	0.577
<b>Dyslipidemia</b>	77.7%	66.0%	<0.001*	72.0%	57.5%	0.008*

\*p<0.05 considered statistically significant

**Table 3. CR Referral and Participation Rates based on Pre-CR and Post-CR Cohorts.**

	CR Referrals		CR Participation	
	Week 1	Week 12	Week 1	Week 12
Pre-CR	38.6%	54.1%	9.9%	39.4%
Post-CR	54.9%	59.8%	7.4%	21.8%
P-value*	0.003	0.386	0.773	0.020

\*p<0.05 considered statistically significant

**Table 4: EOS Cohorts - CR Referral and Participation Rates based on EOS Cohorts.**

	CR Referrals		CR Participation	
	Week 1	Week 12	Week 1	Week 12
Pre-EOS	40.3%	54.9%	7.30%	36.0%
Post-EOS	58.7%	60.4%	10.0%	20.7%
P-value*	0.001	0.394	0.736	0.038

\*p<0.05 considered statistically significant

2.95) and week-12 OR of 1.26 (95% CI 0.79-2.00). Despite such noted increased referral rates, overall participation rates in the post-CR period did not improve compared to pre-CR rates at week-1 (Pre-CR 9.9% and Post-CR 7.4%, p=0.773) or at week-12 (Pre-CR 39.4% and Post-CR 21.9%, p=0.020).

Multivariable analysis of referral and participation data revealed non-Hispanic patients were more likely to be referred to CR than Hispanics at both week-1 with OR of 2.89 (95% CI: 1.42-6.04) and week-12 with OR of 3.30 (95% CI: 1.54-7.36). Similarly, geographic location affected CR referral rates, with those patients living in large metropolitan areas being more likely to be referred at week-12 with OR of 2.00 (95% CI: 1.07-3.78). Lastly, our results revealed cardiothoracic surgeons (OR: 0.46, 95% CI 0.24-0.86) and interventional cardiologist (OR: 0.54, 95% CI: 0.32-0.92) were less likely to refer patients to CR at week-1.

**Effect of EOS on CR referral and participation rates**

The effects of implementing an electronic ordering system were evident in that Post EOS referral rates increased at week-1 (Pre-EOS 40.3% and Post-EOS 58.7%, p<0.001) and week-12 (Pre-EOS 54.9% and Post-EOS 60.4%, p=0.394) with univariate logistic analysis showing patients were more likely to be referred at both week-1 (OR: 2.1, 95% CI 1.4-3.3) and week-12 (OR: 1.25, 95% CI 0.80-1.98). A similar pattern was noted in the multivariable regression analysis when adjusting for confounding factors at both week-1 (OR: 2.2, 95% CI 1.4-3.7) and week 12 (OR: 1.49, 95% CI 0.88-2.53).

Furthermore, multivariable analysis revealed non-Hispanic patients were approximately 3 times more likely to be referred to CR than Hispanics at both week-1 (OR: 2.96, 95% CI: 1.46-6.19) and week-12 (OR: 3.22, 95% CI: 1.51-7.12). Similarly, patients in large metropolitan areas were noted to be more likely to be referred by week-12 (OR: 2.12, 95% CI: 1.13-4.02). Lastly, cardiothoracic surgeons (OR: 0.453, 95% CI 0.240-0.842) and interventional cardiologist (OR: 0.519, 95% CI: 0.305-0.877) were less likely

to refer patients to CR at week-1. A similar trend on referral rates was noted at week-12 for both specialties although such trends did not reach statistical significance at that time interval; interventional cardiology with OR of 0.647 (p = 0.142) and cardiothoracic surgery with OR of 0.547 (p = 0.086).

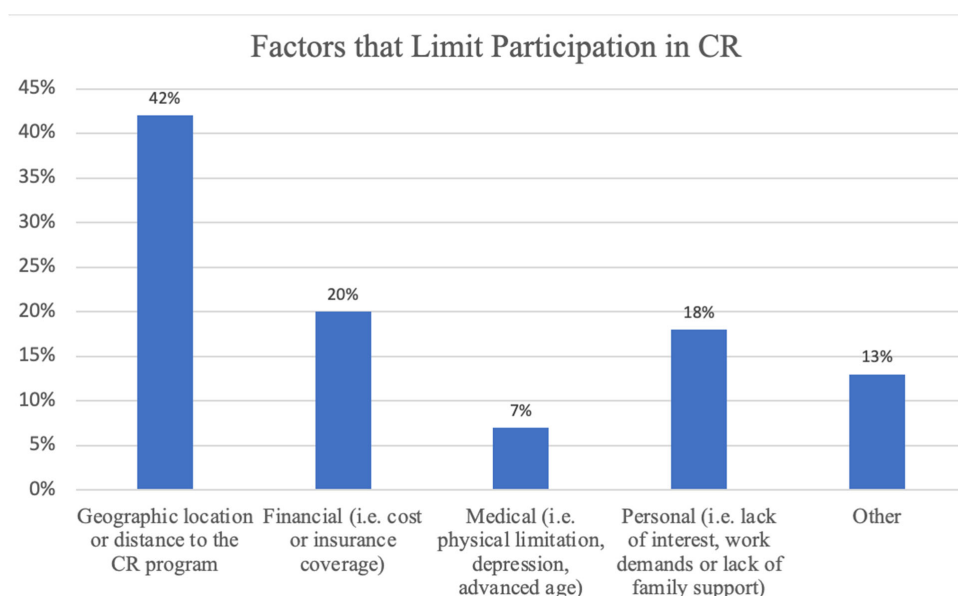
In regard to CR participation, univariate analysis revealed patients with CHD were more likely to participate at both week-1 (OR: 2.1, 95% CI 1.4-3.3) and week-12 (OR: 1.252, 95% CI 0.80-1.96) following the EOS implementation. Notable findings on the multivariable analysis revealed that non-Hispanics were more likely to participate at both week-1 (OR: 2.96, 95% CI 1.46-6.19) and week-12 (OR: 3.22, 95% CI 1.51-7.12) compared to Hispanics and that patients from large metropolitan areas were more likely to participate by week-12 (OR: 2.124, 95% CI 1.131-4.020).

**Discussion**

**Effect of local CR center**

To our knowledge, this is the first prospective cohort study evaluating the independent impact of the availability of a new CR program and the implementation of an automated electronic ordering system (EOS) on CR referral and participation rates. Valencia *et al.* [11] previously characterized the benefits of CR in decreasing cardiac mortality by approximately 25% over 3 years of follow up and 50% decrease in recurrent events 6 months following acute coronary event. Yet, the direct impact of a new CR program with EOS on referral and participation rates has not been fully investigated. In our adjusted analysis comparing the Pre- and Post-CR cohorts, the availability of a local CR program led to an increase in referral rates noted at both week-1 and week-12 in Post-CR; however, such increases in referral rates did not translate into direct enrollment as the overall participation rates decreased in the Post-CR compared to Pre-CR periods. Extraneous factors that may have affected participation include among others, geographical, financial, medical, physical, and personal (see **Figure 2**). Patients’ self-reported factors including geographic barriers (42%), financial costs (20%),





**Figure 2.** Patients' self-reported barriers in participation to CR.

personal issues (18%), other reasons (13%), and medical limitations (7%), all negatively impacted CR participation among our patient population.

#### Effect of EOS implementation

Referral rate improvements were noted both at week-1 (Pre 40.3% and Post 58.7%,  $p < 0.001$ ) and week-12 (Pre 54.9% and Post 60.4%,  $p = 0.394$ ) and were congruent to those published by [8]. In such study 661 patients with ACS were followed with and without an automatic referral system in place and found that the implementation of an EOS led to significantly higher referral rates; 67% compared to 34% using the non-electronic referral method. However, the association between EOS implementation and participation rate has not been reported in the literature. Our analysis showed that at week-1, patients were more likely to participate in CR in Post- vs. Pre- EOS. Yet, at week-12, there was a decline in CR participation rate. It remains unclear as to the specific factors contributing to such decline in participation rates but we suspect cost, distance to CR center, and even loss of interest may be significant factors contributing to these findings.

#### Disparities in referring physician, ethnicity, geography

CR is an effective therapy for the treatment of CHD and yet there is underutilization amongst racial and ethnic minorities [12-14]. Research has shown that racial and ethnic groups with CHD are less likely to participate in CR compared to white patients; factors such as annual earned income, rural predominance of non-white patients, and language barriers contribute to this divide [15]. Racial and Ethnic minority status predicts lower referral rates to CR; The American Heart Association showed that 39% of Hispanics are referred by their physicians compared to 56% and 58% of Black and white populations respectively [16]. A similar pattern emerged on an analysis of 601,000 Medicare patients which showed greater participation rates among whites vs. non-whites after MI or coronary artery bypass graft surgery [5]. Additionally, it has been noted

healthcare providers also play a key role in propagating disparities in medical treatment of cardiac rehabilitation by being the ones in control of referrals [13,17].

This study found similar disparities in referral and participation disparities within the population evaluated. On both CR and EOS cohorts, White patients were more likely to be referred and participate in CR than Hispanics at week-1 and week-12. Concordant with past research [11,18], geographical location impacted referral and participation rates as we noted that by week-12 in our EOS cohort, patients from urban areas were more likely to be referred to CR than patients from rural areas. Lastly, in both the CR and EOS cohorts, at week-1, general cardiologists were twice more likely to refer patients to CR than cardiothoracic surgeons ( $p = 0.013$ ) and interventional cardiologists ( $p = 0.015$ ). These results show how even physician specialty can impact CR referral likelihood.

#### Clinical and policy implications

Patients with CHD benefit from a CR program that encompasses physical and mental health and wellness, but CR referral and participation are surprisingly low. Our results suggest that implementation of a local CR program and EOS are associated with improved CR referral rates. Further studies are needed to focus on improving CR enrollment and participation and understanding the barriers for the low enrollment rates after initial referral. We proposed further evaluation of EOS on CR referral rates among racial and ethnic minority groups as well as populations living in rural settings.

Given the relatively low percentage of patients with CHD who participate in supervised hospital-based CR, alternative approaches to provide CR have been recommended by cardiovascular societies [19-21]. The convenience of a home-based CR program may increase participation rates in patients who have limited access to traditional CR programs [21]. Several CR models of delivery services that include home-based programs, internet-based modules,

and community-based group programs with guidance by nurses and health professionals, provide alternative paradigms that may increase patient participation in CR [13]. Specifically, home-based programs appear to provide an excellent alternative to patients with geographical, financial, and social limitations such as those served at our institution without compromising the proven benefits of CR [20,21].

### Study limitations

Our analysis was limited by a sample size of 360 patients from four quaternary hospitals in Southern California, which limits the statistical power of the study and analysis. Additionally, the study was not blinded and this could have influenced CR referral patterns by physicians. It is plausible that CR enrollment and participation might have been affected by insurance coverage which we recognize to be an important as well as a possible confounding factor in our study. Future studies should include insurance status in order to assess the impact of this important variable on CR referral, enrollment, and participation rates. This study is vulnerable to secular trends, given it is a pre-post study.

### Conclusion

This prospective study investigated the effects of implementing a local cardiac rehabilitation program and an electronic ordering system for patients hospitalized with CHD. Our analysis revealed increased CR referral rates at week-1 and week-12 with long-term potential of increasing referral rates amongst patients with CHD. Factors such as patient's ethnic background, home geography and specialty of referring physician appear to be significant contributors to low referral and participation rates. Local CR programs and the implementation of EOS may extend the positive impact of CR for patients with CHD as well as ameliorate underlying cardiovascular health disparities that affect racial and ethnic groups.

### Conflict of Interest

There is no financial conflict of interest for any authors who contributed to this manuscript.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Sources of Funding

Hispanic Center of Excellence Scholars Scholarship for Research Grant and Award, 2019.

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