Geisinger Virtual Cardiac Rehabilitation Study
Abstract

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During the COVID-19 public health emergency (PHE), Geisinger referred patients requiring cardiac rehab (CR) to a virtual/telehealth program. We aim to publish this data in a peer-reviewed publication later this year. We are happy to be reached for further comment or questions regarding this data or its analysis.

Population
The intervention group consists of those patients meeting CR eligibility and enrolled in a virtual CR program. The virtual program consists of real-time, audio-visual (synchronous) encounters, with virtual direct physician supervision, delivered in accordance with the regulations in 42 CFR 410.49.

The primary comparison group consists of those patients meeting eligibility for CR and enrolled in a center-based CR (in-person) program delivered in accordance with the regulations in 42 CFR 410.49.

Additionally, patients who were referred for CR but did not participate in CR care were included in an additional comparison group.

Study Design
Retrospective, observational study using electronic health record (EHR) and administrative claims data. Baseline variables were determined at enrollment into CR or at time of referral for the CR referral only group.

Baseline Variables to describe the patient population at enrollment.

- Demographics
- Insurance type
- Presence/absence of chronic conditions that make up the Elixhauser Comorbidity Index
- Costs allowed in prior 12 months (medical, pharmacy, total), obtained from a subset of patients where we had cost data on (affiliated health plan).

Outcome Variables

- Costs: Total medical allowed, pharmacy, and total costs of care over 12 months post-enrollment.
- Health/Utilization: Hospital admission, ED admission, Myocardial infarction, Mortality within 1 year

Analysis

The goal of the analysis is to compare patient costs and health outcomes between those enrolled in center-based CR to virtual CR to CR referral only (no rehab). As this is a non-randomized design, we employ methods for observational data analysis. We start with characterizing the patients within each group to determine the balance of baseline covariates. If there is an imbalance, which we expect, then we will fit a regression model using CR program type (center-based, virtual, referral only) as the outcome. The model will include all available baseline covariates. The propensity score (PS) is then estimated from the model and is used to weight the patient observations. This creates a pseudo-population that is balanced on all measured baseline covariates.

After balancing the baseline covariates, weighted Gamma regression models that include an offset for the number of follow-up months will be used for the cost outcomes. The health outcomes will use a time-to-event analysis to estimate the incident rate (#/10,000 patient days of follow-up). Results are reported as the average PMPM with 95% confidence intervals (CIs) for costs, and incident rate and incident rate ratio with 95% CIs for the health outcomes. The comparison of costs between groups is accomplished by testing the ratio of the averages due to the type of CR program.

Results

There were a total of 703 virtual CR patients, compared to 2303 center-based CR patients, and 10,922 patients that were referred but did not enter CR. Due to the small number of hospital and ED admissions, these outcomes were summarized as time from start of CR until the first occurrence within 1 year. This is then described as the number of admissions per 10,000 patient days (an incident rate) and compared between the groups using the incident rate ratio (IRR). An IRR < 1.0 indicates a lower rate in the virtual cardiac rehab group. Baseline variables are shown in Table 1.

Costs of Care (Table 2)

Cost data was available on 220 virtual CR patients, 375 center-based CR patients, and 2216 CR Referral only patients. Table 2 reports the PS-weighted comparisons between the groups for the 12-month cost outcomes using cost ratios. Total medical allowed and total costs allowed were found to be reduced in the virtual CR program compared to center-based CR. More specifically, total medical allowed in the virtual CR program was observed to have 18.6% reduction in the average PMPM costs across the 12 months after enrollment (p=0.0144). Similarly, the total costs allowed in 16.2% lower in virtual CR compared to center-based CR (p=0.0176).

Utilization and Health Outcomes (Table 3)

There was a significant reduction in the incidence of hospital and ED visits within 1 year in the virtual group compared to the center-based group. For hospital admissions, the incidence rate was 14.9 vs. 24.2 per 100 patient-years, respectively (Table 3). This corresponds to an incident rate ratio (IRR) of 0.616 (95% CI: 0.489, 0.777, p<0.0001) or a **38% reduction in hospital admissions**. Similarly, for ED admissions the incidence rate was 26.8 vs. 48.0 per 100 patient-years, respectively, for an IRR of 0.557 (0.452, 0.687, p<0.0001). This corresponds to a **44% reduction in ED utilization**. There were no statistically significant differences in the incidence of myocardial infarction or 1-year mortality.

As expected, we observed increases in readmission (13.9%) and mortality (54.1%) in the CR Referral Only group (no CR) as compared to the center-based CR group.

This evaluation is not without limitations. For example, we are only able to account for confounding on measured covariates. Any important non-measured confounding baseline variables may account for any differences observed.

Table 1: Demographic and Medical Characteristics Stratified by Cardiac Rehab Group.

	Center-Based (N=2303)	*Virtual (N=703)*	*CR Referral (N=10922)*	*P-value*
Age (years)				<.0001[1]
Mean (SD)	66.9 (11.35)	70.3 (10.83)	67.5 (12.43)	
Female sex, n (%)	749 (32.4%)	269 (38.3%)	3529 (32.1%)	0.0031[2]
Patient race, n (%)				0.0016[2]
White	2261 (98.2%)	673 (96.8%)	10589 (96.8%)	
Non-white	41 (1.8%)	22 (3.2%)	346 (3.2%)	
Patient ethnicity, n (%)				<.0001[2]
Non-Hispanic/Latino	2278 (99.4%)	675 (97.5%)	10624 (97.6%)	
Latino/Hispanic	14 (0.6%)	17 (2.5%)	262 (2.4%)	
History of HTN, n (%)				<.0001[2]
Yes	1427 (61.7%)	546 (77.7%)	6815 (61.9%)	
History of hyperlipidemia, n (%)	1311 (56.7%)	490 (69.7%)	5792 (52.6%)	<.0001[2]
History of diabetes, n (%)	664 (28.7%)	268 (38.1%)	3096 (28.1%)	<.0001[2]
History of MI, n (%)	1044 (45.1%)	288 (41.0%)	4891 (44.5%)	0.1441[2]
History of CAD, n (%)	1538 (66.5%)	602 (85.6%)	7903 (71.8%)	<.0001[2]
History of CHF, n (%)	445 (19.2%)	204 (29.0%)	2604 (23.7%)	<.0001[2]
History of CKD, n (%)	751 (32.5%)	335 (47.7%)	3973 (36.1%)	<.0001[2]
Alcohol abuse, n (%)	93 (4.0%)	40 (5.7%)	583 (5.3%)	0.0295[2]
Anemias due to other nutritional deficiencies, n (%)	392 (17.0%)	188 (26.7%)	2189 (20.0%)	<.0001[2]
Autoimmune conditions, n (%)	123 (5.3%)	53 (7.5%)	624 (5.7%)	0.0865[2]
Chronic blood loss (iron deficiency), n (%)	60 (2.6%)	23 (3.3%)	284 (2.6%)	0.5571[2]
Leukemia, n (%)	18 (0.8%)	5 (0.7%)	91 (0.8%)	0.9198[2]
Lymphoma, n (%)	23 (1.0%)	15 (2.1%)	148 (1.4%)	0.0667[2]
Metastatic cancer, n (%)	18 (0.8%)	12 (1.7%)	121 (1.1%)	0.1020[2]
Solid tumor without metastasis, in situ, n (%)	56 (2.4%)	23 (3.3%)	174 (1.6%)	0.0003[2]
Solid tumor without metastasis, malignant, n (%)	232 (10.1%)	109 (15.5%)	1036 (9.5%)	<.0001[2]

	Center-Based (N=2303)	*Virtual (N=703)*	*CR Referral (N=10922)*	*P-value*
Cerebrovascular disease, n (%)	373 (16.2%)	127 (18.1%)	1799 (16.5%)	0.4940[2]
Coagulopathy, n (%)	217 (9.4%)	96 (13.7%)	1249 (11.4%)	0.0023[2]
Dementia, n (%)	61 (2.6%)	32 (4.6%)	373 (3.4%)	0.0336[2]
Depression, n (%)	469 (20.4%)	164 (23.3%)	2225 (20.4%)	0.1668[2]
Diabetes with chronic complications, n (%)	590 (25.6%)	251 (35.7%)	2992 (27.4%)	<.0001[2]
Diabetes without chronic complications, n (%)	807 (35.0%)	302 (43.0%)	3807 (34.9%)	<.0001[2]
Drug abuse, n (%)	41 (1.8%)	19 (2.7%)	351 (3.2%)	0.0010[2]
Hypertension, uncomplicated, n (%)	1756 (76.2%)	599 (85.2%)	8198 (75.1%)	<.0001[2]
Heart failure, n (%)	693 (30.1%)	282 (40.1%)	3961 (36.3%)	<.0001[2]
Hypertension, complicated, n (%)	807 (35.0%)	341 (48.5%)	4267 (39.1%)	<.0001[2]
Liver disease, mild, n (%)	202 (8.8%)	96 (13.7%)	955 (8.7%)	<.0001[2]
Liver disease and failure, moderate to severe, n (%)	16 (0.7%)	7 (1.0%)	138 (1.3%)	0.0623[2]
Chronic pulmonary disease, n (%)	530 (23.0%)	224 (31.9%)	2819 (25.8%)	<.0001[2]
Neurological disorders affecting movement, n (%)	77 (3.3%)	30 (4.3%)	469 (4.3%)	0.1126[2]
Other neurological disorders, n (%)	101 (4.4%)	53 (7.5%)	687 (6.3%)	0.0005[2]
Seizures and epilepsy, n (%)	63 (2.7%)	23 (3.3%)	285 (2.6%)	0.5565[2]
Obesity, n (%)	972 (42.2%)	341 (48.5%)	3952 (36.2%)	<.0001[2]
Paralysis, n (%)	69 (3.0%)	19 (2.7%)	358 (3.3%)	0.5819[2]
Peripheral vascular disease, n (%)	659 (28.6%)	297 (42.2%)	3586 (32.8%)	<.0001[2]
Psychoses, n (%)		131 (5.7%)	52 (7.4%)	666 (6.1%)
Pulmonary circulation disease, n (%)	182 (7.9%)	59 (8.4%)	1032 (9.4%)	0.0505[2]
Renal (kidney) failure and disease, moderate, n (%)	512 (22.2%)	233 (33.1%)	2685 (24.6%)	<.0001[2]
Renal (kidney) failure and disease, severe, n (%)	79 (3.4%)	43 (6.1%)	622 (5.7%)	<.0001[2]
Hypothyroidism, n (%)	410 (17.8%)	157 (22.3%)	1858 (17.0%)	0.0013[2]
Other thyroid disorders, n (%)	128 (5.6%)	59 (8.4%)	503 (4.6%)	<.0001[2]

	Center-Based (N=2303)	*Virtual (N=703)*	*CR Referral (N=10922)*	*P-value*
Peptic ulcer with bleeding, n (%)	62 (2.7%)	24 (3.4%)	330 (3.0%)	0.5549[2]
Valvular disease, n (%)	657 (28.5%)	269 (38.3%)	3984 (36.5%)	<.0001[2]
Weight loss, n (%)	132 (5.7%)	53 (7.5%)	767 (7.0%)	0.0623[2]

[1]Kruskal-Wallis p-value; [2]Chi-Square p-value;

Table 2: Weighted Analysis of Cost Ratio

	Cost Ratio VCR/CBCR	**p**
Total Medical Costs at 1 year	0.814 (0.690, 0.960)	**0.0144**
Total RX Costs at 1 year	0.928 (0.753, 1.143)	0.4834
Total Costs of Care at 1 year	0.838 (0.725, 0.970)	**0.0176**

Table 3: Weighted Analysis of Health Outcomes

Readmission 1 Year	Center-based CR (n=2303)	Virtual CR (n=703)	CR Referral Only (n=10922)
Number of Events*	444	118	2501
Incidence Rate (per 100 patient years)	24.2 (21.9, 26.7)	14.9 (12.1, 18.4)	27.5 (26.4, 28.7)
Incident Rate Ratio	---	0.616 (0.489, 0.777) **P<0.0001**	1.139 (1.022, 1.268) P=0.0182
ED Admission 1 Year			
Number of Events*	806	150	2830
Incidence Rate (per 100 patient years)	48.0 (44.5, 51.8)	26.8 (22.0, 32.5)	32.2 (30.9, 33.4)
Incident Rate Ratio	---	0.557 (0.452, 0.687) **P<0.0001**	0.670 (0.615, 0.728) P<0.0001
MI 1 Year			
Number of Events*	30	10	193
Incidence Rate (per 100 patient years)	1.4 (0.9, 2.1)	1.8 (0.8, 3.7)	1.8 (1.6, 2.1)
Incident Rate Ratio	---	1.250 (0.535, 2.914) P=0.6050	1.307 (0.863, 1.979) P=0.2062
Mortality 1 Year			
Number of Events*	57	16	540
Incidence Rate (per 100 patient years)	3.3 (2.5, 4.3)	2.0 (1.2, 3.4)	5.0 (4.6, 5.5)
Incident Rate Ratio	---	0.618 (0.345, 1.104) P=0.1040	1.541 (1.150, 2.066) P=0.0038
Number of CR Encounters	21.4 (20.9, 22.0)	34.4 (34.0, 34.7)	N/A
Ratio	---	1.605 (1.561, 1.650) P<0.0001	---

* unweighted number of events