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Prevalence and impact of cognitive impairment assessed by Mini-Cog in hospitalized cardiac rehabilitation referrals

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ABSTRACT

Introduction and objectives: Evaluate patients referred for cardiac rehabilitation to determine the prevalence of cognitive impairment (CI) and compare readmission rates and mortality for those with and without CI.

Methods: Patients were retrospectively divided into cohort A (Mini-Cog completed) and cohort B (Mini-Cog not completed). Cohort A was then divided into A_1 (Mini-Cog positive for CI) and A_2 (Mini-Cog negative for CI).

Results: Of 1440 patients, 986 (68%) completed the Mini-Cog (cohort A) and 454 (32%) patients did not (cohort B). Within cohort A, 46 (4.7%) had a positive Mini-Cog (cohort A_1) and 940 (95.3%) had a negative Mini-Cog (cohort A_2). Cohort A_1 had significantly higher rates of all-cause readmission compared with cohorts A_2 and B (63% vs 44% and 47%; $P = .02$), and significantly higher mortality (28% vs 9% vs 15%; $P < .001$), but was also significantly older, with more co-morbidities. After accounting for demographic and co-morbidity differences between cohorts A_1 and A_2 using propensity score matching and Cox proportional hazards model, cohort A_1 had significantly increased rates of the composite outcome of readmission and/or death at 3-months ($P = .002$).

Conclusions: Poor performance on the Mini-Cog identified an older group of phase I cardiac rehabilitation patients that had significantly increased rates of the combined end-point of readmission plus death.

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Prevalencia e impacto del deterioro cognitivo evaluado por Mini-Cog en las derivaciones hospitalarias a rehabilitación cardiaca

Palabras clave:
Deterioro cognitivo
Mini-Cog
Rehabilitación cardiaca

RESUMEN

Introducción y objetivos: Evaluar pacientes derivados a rehabilitación cardiaca para determinar la prevalencia de deterioro cognitivo (DC) y comparar tasas de reingreso y mortalidad entre aquellos con y sin DC.

Métodos: Se dividió a los pacientes retrospectivamente en cohorte A (Mini-Cog completado) y cohorte B (Mini-Cog no completado). La cohorte A se dividió a su vez en A1 (Mini-Cog positivo para DC) y A2 (Mini-Cog negativo para DC).

Resultados: De 1.440 pacientes, 986 (68%) completaron el Mini-Cog (cohorte A) y 454 (32%) pacientes no lo hicieron (Cohorte B). Dentro de la cohorte A, 46 (4,7%) tenían un Mini-Cog positive para DC (cohorte A1) y 940 (95,3%) tenían un Mini-Cog negativo (cohorte A2). La cohorte A1 tuvo tasas significativamente más altas de reingreso por cualquier causa en comparación con las cohortes A2 y B (63 frente a 44% y 47%; p = 0,02) y una mortalidad significativamente mayor (28 frente a 9 frente a 15%; p < 0,001), pero los pacientes también eran significativamente más mayores y con más comorbilidades. Después de tener en cuenta las diferencias demográficas y la comorbilidad entre las cohortes A1 y A2 mediante el emparejamiento por puntuación de propensión y el modelo de riesgos proporcionales de Cox, la cohorte A1 aumentó significativamente las tasas de reingreso o muerte a los 3 meses (p = 0,002).

Conclusiones: Un resultado deficiente en el Mini-Cog identificó a un grupo de pacientes de rehabilitación cardiaca en fase I más ancianos con tasas de eventos combinados de reingresos y muerte significativamente mayores.

Introduction

Mild cognitive impairment is a pre-cursor to dementia and Alzheimer's disease.[1] Cognitive impairment is associated with increased rates of readmission, longer hospitalizations, and increased mortality in elderly patients.[2–4]

The Mini-Cog test is a quick and easy test that has been shown to have good accuracy at identifying cognitive impairment.[4,5] Several cardiac populations with cognitive impairment, identified on Mini-Cog, have poor post-hospital discharge outcomes.[6–10] While cognitive impairment is shown to be fairly common in heart failure patients, it is less established what the prevalence is in a broader cardiology cohort, and how significantly it impacts mortality and readmission rates in this broader population.[8–12]

Since April of 2015 the cardiopulmonary rehabilitation therapists at our institution have administered the Mini-Cog test to patients referred for inpatient (phase I) cardiopulmonary rehabilitation. Our study aims were to evaluate a large, consecutive cohort of patients referred for cardiopulmonary rehabilitation and determine the prevalence of cognitive impairment and compare readmission rates and mortality for those with and without cognitive impairment. We hypothesized that hospitalized patients receiving cardiopulmonary rehabilitation that perform poorly on the Mini-Cog would identify a group at high-risk for readmission and death.

Methods

The Mini-Cog exam was prospectively ordered on 1627 consecutive cardiopulmonary rehabilitation patient encounters from 1 March 2016 to 28 February 2017 (Fig. 1). Each patient's electronic medical record (EMR, Epic, United States) was retrospectively reviewed to collect and record study data. The institutional review board approved the study with a waiver of patient consent. Seven patients were excluded from the study cohort, as they died during their index admission. There were 152 patients that had more than one phase I cardiopulmonary rehabilitation order during the study period. Only the initial Mini-Cog score and associated data were included to remove duplicate patients from contributing to the outcome data.

Mini-Cog exam

The cardiopulmonary rehabilitation therapist administered the exam to patients using the following protocol:

- Instruct the patient to listen carefully and remember the following three words: table, car, orange.
- The patient was then provided with a paper that had a blank circle and instructed to draw the face of a clock.
- Once the clock face was drawn then the patient was instructed to position the hands of the clock to a time of 9:10.

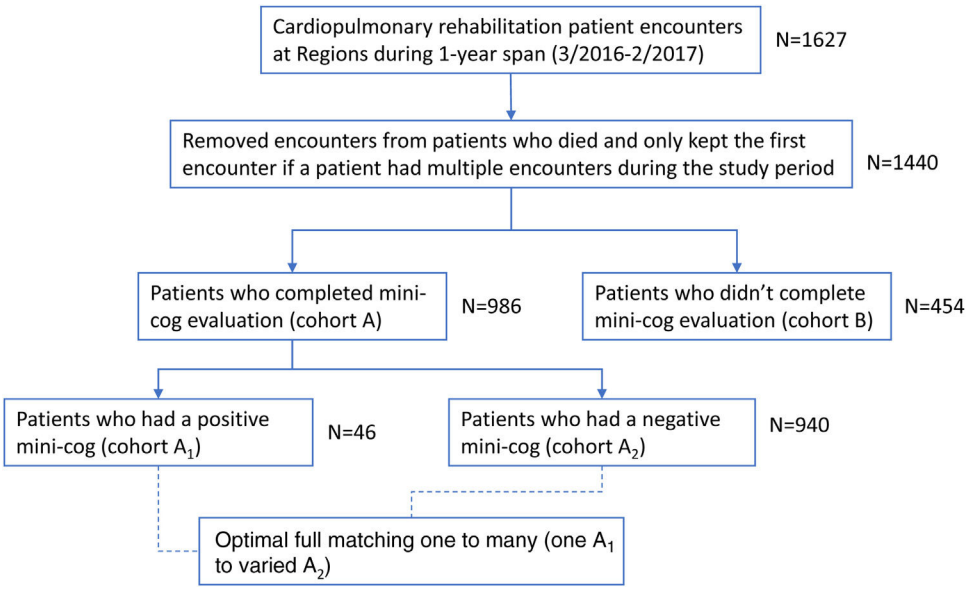

Fig. 1 – Flow diagram of study subjects.

- The patient was then asked to recite the three memory words.

Mini-Cog exam scoring

- One-point for each word correctly recalled, for a possible total of three points.
- One-point for correctly drawing the clock face.
- One-point for correctly positioning the clock hands to demonstrate a time of 9:10.
- A score of 2 or less was considered a positive Mini-Cog screen for cognitive impairment. The patient's registered nurse was notified of abnormal test results.
- A score of 3 or higher was considered negative for cognitive impairment.

Once the final cohort was created patients were then divided into cohort A (Mini-Cog completed) and cohort B (Mini-Cog not completed). Cohort A was then further divided into A_1 (Mini-Cog positive for cognitive impairment, with a score of 2 or less) and A_2 (Mini-Cog negative for cognitive impairment, with a score of 3 or better). Patients were followed in their EMR through a censure date of 31 October 2017 to evaluate for readmissions to HealthPartners Hospitals (HealthPartners is an integrated healthcare system based in Minnesota and Western Wisconsin that includes 8 hospitals). Care Everywhere was used to identify hospitalizations that occurred outside the HealthPartners system. The Minnesota Department of Health's Death Search was utilized to determine any deaths occurring prior to our censure date – 31 October 2017. To assess for death in Western Wisconsin residents lost to follow-up, we evaluated obituaries in local newspapers.

Statistics

Continuous data are presented as mean ± one standard deviation. Categorical data are presented as numbers, with percentages provided in parenthesis. Comparisons were performed using a *t*-test, contingency table, analysis of variance or Chi-square. A $P\text{-}value \leq .05$ was considered statistically significant.

Age, gender, and co-morbidities differed between groups (A_1 and A_2). Therefore, we used propensity score matching to mimic a randomized clinical trial to control for the impact of these potential confounders on the treatment assignment (A_1 and A_2) and the outcome. We matched on age, gender and 9 different co-morbidities: hypertension, hyperlipidemia, diabetes mellitus, coronary artery disease, chronic kidney disease, chronic obstructive pulmonary disease, congestive heart failure, cerebrovascular accident, and current smoking. We first attempted 3 main methods of matching: nearest neighbor matching, optimal full matching, and exact matching. Nearest neighbor matching method was also tested on 5 different specifications: greedy nearest neighbor with logistic regression for propensity score, nearest neighbor with caliper, with ratio *k*:1 matching, matching with probit regression for propensity score, and nearest neighbor with fixed ratio. Full matching method was also tried with both logit and probit. To avoid discarding observations and generalize to target population ATE (average treatment effect in the population), we eventually chose optimal full matching method (one-to-many) with logistic regression for propensity score.

Propensity score matching was conducted to balance covariates between two groups, however, at the end for estimating treatment effect, we chose Cox proportional hazards model over other survival analyses so that we again included covariates used in matching to give additional robustness to a small number of imbalances remaining after matching. As a result, we could reduce bias due to residual imbalance, increase the precision of effect estimate and make the result "doubly robust" where we can check if either matching process or outcome model has reduced imbalance correctly.[13] We conducted a sensitivity analysis to ensure that the study outcome was robust to hidden bias from unobserved confounders.

Table 1 – Clinical characteristics.

Variables	Cohort A1 (*n* = 46)	Cohort A2 (*n* = 940)	Cohort B (*n* = 454)	P	A1 vs A2 P
Age	77 ± 12	66 ± 13	69 ± 14	<.001	<.001
Female sex	27 (59)	329 (35)	215 (47)	<.001	.001
Hypertension	41 (89)	746 (79)	350 (77)	.14	.13
Hyperlipidemia	35 (76)	740 (79)	319 (70)	.002	.71
Diabetes	17 (37)	304 (32)	153 (34)	.73	.52
Coronary artery disease	29 (63)	681 (72)	247 (54)	<.001	.17
Chronic kidney disease	30 (65)	249 (26)	148 (33)	<.001	<.001
COPD	12 (26)	123 (13)	89 (20)	<.001	.02
CHF	27 (59)	303 (32)	128 (28)	<.001	<.001
CVA	6 (13)	66 (7)	49 (11)	.03	.13
LVEF	49 ± 17	50 ± 14	54 ± 14	<.001	.63
Current smoker	8 (17)	196 (21)	76 (17)	.17	.71
Previous smoker	21 (46)	432 (46)	199 (44)	.75	1
Non-smoker	18 (39)	312 (33)	179 (39)	.06	.42
Minnesota residence	34 (74)	661 (70)	347 (76)	.06	.74

Data are presented as average ± standard deviation, or number with percentage shown in parenthesis. A *P*-value ≤ .05 was considered statistically significant. CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; LVEF, left ventricular ejection fraction.

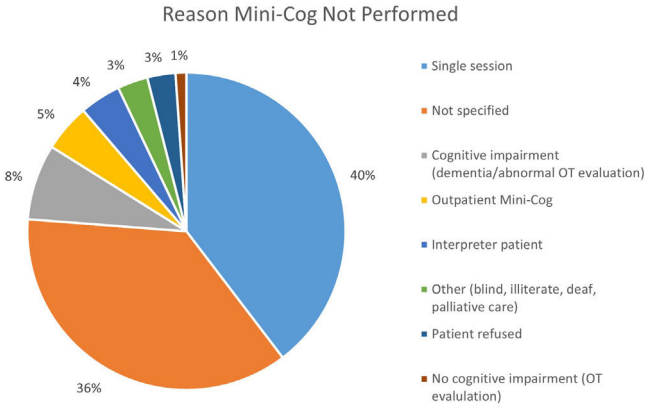

Fig. 2 – Reasons Mini-Cog not administered. OT, occupational therapy.

All analyses were performed using R v4.2.2 (R-Project, Austria). The MatchIt package Nonparametric Preprocessing for Parametric Causal Inference (Matchlt, United States) was used for propensity score matching.

Results

Of the 1440 patients, 986 (68%) completed the Mini-Cog (cohort A), with 46 (4.7%) positive Mini-Cog (cohort A_1) and the remaining 940 (95.3%) having a negative Mini-Cog (cohort A_2). The 95% confidence interval for the prevalence of a positive Mini-Cog was 3.4–6.1%. Cohort B includes 454 patients that did not perform the Mini-Cog. Reasons that the Mini-Cog was not completed are shown in Fig. 2. There were 22 patients in cohort B that completed the Mini-Cog but did so as an outpatient prior to admission. Of these 22 patients, 1 (4.5%) had a positive Mini-Cog. Cohort A_1 was significantly older, more frequently female, with more chronic kidney disease, heart failure, and chronic obstructive pulmonary disease than the other cohorts. Baseline demographic data for the groups are shown in Table 1.

On univariate analysis cohort A_1 had significantly higher rates of all-cause readmission compared with cohorts A_2 and B (63% vs 44% and 47%; *P* = .02), and significantly higher mortality (28% vs 9% vs 15%; *P* < .001) (Table 2).

Before matching, there was a large imbalance of covariates between A1 and A2 ranging from 0.1 to 0.87 (absolute value of standardized mean differences) and empirical cumulative density functions max (eCDF max) mostly were ranging from 0.1 to 0.46 (Table 3). Optimal full matching yielded the best balance between two groups, as indicated in Table 4. Sample size remained intact, with the distribution of propensity score shown in Fig. 3. After matching all standardized mean differences and empirical cumulative density functions max (eCDF max) for covariates were all below 0.08 (except one value was 0.11), variance ratios were close to 1. Standardized mean difference plot is indicated in Fig. 4.

Survival curves analyzing freedom from the composite outcome of readmission plus death for matched cohorts are shown in Fig. 5. At the 3-month follow-up period in Cox proportional hazards model, cohort A_1 had significantly more readmission and death compared to cohort A_2 (*P* = .002). That is, at a given instant in time a patient with positive Mini-Cog is 93.7% times as likely to die or get readmitted to hospital as a patient with negative Mini-Cog adjusting for age, gender and 9 different co-morbidities (95% confidence interval, 1.262–2.974). The result for the entire follow-up period was not significant.

Assessing the Mini-Cog score as a continuous variable revealed progressive increases in death and the composite of death and readmission, along with progressive, significant increases in age, hypertension, chronic kidney disease, diabetes mellitus, and cerebrovascular accident (Tables 5 and 6).

Sub-group analysis found 9.5% of those ≥70 years of age had cognitive impairment. Patients ≥ 70 years of age, with a positive Mini-Cog had higher rates of all-cause readmission and death compared to patients ≥ 70 years of age with a nega-

Table 2 – Outcome data.

Variables	Cohort A1 ($n = 46$)	Cohort A2 ($n = 940$)	Cohort B ($n = 454$)	P	A1 vs A2 P
LOS index admission (days)	6 ± 5	5 ± 4	5 ± 4	.25	.10
Follow-up duration (months)	11.5 ± 6.4	12.4 ± 5.2	11.8 ± 5.7	.10	.25
Incomplete follow-up	3 (6.5)	119 (12.6)	50 (10.9)	.34	.35
30-Day ED visit	13 (28)	198 (21)	81 (18)	.14	.26
30-Day cardiac readmission	9 (20)	122 (13)	50 (11)	.20	.18
30-Day all-cause readmission	12 (26)	156 (17)	70 (15)	.17	.10
Cardiac readmission prior to censure	21 (46)	309 (33)	140 (31)	.12	.07
All-cause readmission prior to censure	29 (63)	409 (44)	212 (47)	.02	.009
Death	13 (28)	80 (9)	68 (15)	<.001	<.001
Composite outcome	34 (74)	463 (49)	236 (52)	.004	.001

Data are presented as average ± standard deviation, or number with percentage shown in parenthesis. A P-value ≤ .05 was considered statistically significant. ED, emergency department; LOS, length of stay.

Table 3 – Summary of balance for all covariates before matching.

Covariates	Means treated (positive Mini-Cog)	Means control (negative Mini-Cog)	Standardized mean difference	Variance ratio	eCDF mean	eCDF max
Distance	0.1067	0.0437	0.9330	1.6208	0.3083	0.5311
Female sex	0.5870	0.3500	0.4812		0.2370	0.2370
Male sex	0.4130	0.6500	−0.4812		0.2370	0.2370
Age	76.6957	65.9819	0.8754	0.8744	0.1486	0.4615
HTN	0.8913	0.7936	0.3138		0.0977	0.0977
Hyperlipidemia	0.7609	0.7872	−0.0618		0.0264	0.0264
Diabetes	0.3696	0.3234	0.0956		0.0462	0.0462
CAD	0.6304	0.7245	−0.1948		0.0940	0.0940
CKD	0.6522	0.2649	0.8131		0.3873	0.3873
COPD	0.2609	0.1309	0.2961		0.1300	0.1300
CHF	0.5870	0.3223	0.5374		0.2646	0.2646
CVA	0.1304	0.0702	0.1788		0.0602	0.0602
Current smoking	0.1739	0.2085	−0.0913		0.0346	0.0346

CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; eCDF, empirical cumulative density functions; HTN, hypertension.

Table 4 – Summary of balance for all covariates after optimal full matching.

Variables	Means treated (positive Mini-Cog)	Means control (negative Mini-Cog)	Standardized mean difference	Variance ratio	eCDF mean	eCDF max	Standard pair difference
Distance	0.1067	0.1065	0.0041	1.0220	0.0080	0.0652	0.0263
Female sex	0.5870	0.5434	0.0885		0.0436	0.0436	0.7454
Male sex	0.4130	0.4566	−0.0885		0.0436	0.0436	0.7454
Age	76.6957	76.0574	0.0521	1.1136	0.0321	0.1163	0.7816
HTN	0.8913	0.8872	0.0131		0.0041	0.0041	0.9809
Hyperlipidemia	0.7609	0.7364	0.0573		0.0244	0.0244	1.0176
Diabetes	0.3696	0.3859	−0.0338		0.0163	0.0163	0.8089
CAD	0.6304	0.5953	0.0728		0.0351	0.0351	0.8309
CKD	0.6522	0.6668	−0.0308		0.0147	0.0147	0.4043
COPD	0.2609	0.2672	−0.0144		0.0063	0.0063	0.4167
CHF	0.5870	0.6036	−0.0339		0.0167	0.0167	0.6763
CVA	0.1304	0.1144	0.0475		0.0160	0.0160	0.6634
Current smoking	0.1739	0.2045	−0.0806		0.0306	0.0306	1.2434

CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; eCDF, empirical cumulative density functions; HTN, hypertension.

tive Mini-Cog, but significant differences between the cohorts remained. Of those ≥80 years of age, 12.3% had cognitive impairment. The baseline characteristics were very similar between those with and without a positive Mini-Cog and ≥80 years of age, with no difference in readmission or death. Of the 590 patients < 70 years of age, 8 (1.3%) had cognitive impairment.

Within cohort B were 35 (8%) patients that either had a history of dementia/cognitive impairment or had a Montreal Cognitive Assessment (MoCA) administered by an occupa-

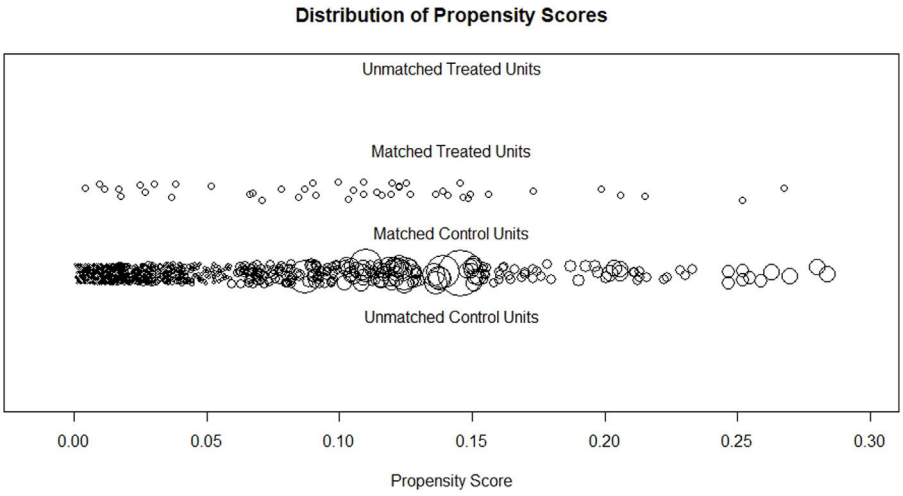

Fig. 3 – Distribution of propensity scores.

Table 5 – Clinical characteristics.

Variables	Mini-Cog 5 ($n = 558$)	Mini-Cog 4 ($n = 251$)	Mini-Cog 3 ($n = 131$)	Mini-Cog 2 ($n = 32$)	Mini-Cog 1 ($n = 11$)	Mini-Cog 0 ($n = 3$)	P
Age	64 ± 13	67 ± 13	72 ± 13	75 ± 14	78 ± 5	84 ± 6	< .001
Female sex	191 (34)	77 (31)	61 (47)	19 (59)	6 (55)	2 (67)	< .001
Hypertension	421 (75)	212 (84)	113 (86)	28 (88)	10 (91)	3 (100)	.01
Hyperlipidemia	440 (79)	202 (80)	98 (75)	23 (72)	9 (82)	3 (100)	.86
Diabetes	175 (31)	78 (31)	51 (39)	6 (19)	9 (82)	2 (67)	.009
Coronary artery disease	411 (74)	182 (73)	88 (67)	19 (59)	9 (82)	1 (33)	.44
Chronic kidney disease	114 (20)	876 (34)	49 (37)	20 (63)	9 (82)	1 (33)	NaN
COPD	58 (10)	37 (15)	28 (21)	8 (25)	4 (36)	0	.005
CHF	145 (26)	98 (39)	60 (46)	17 (53)	9 (82)	1 (33)	< .001
CVA	29 (5)	22 (9)	15 (11)	3 (9)	1 (9)	2 (67)	.01
LVEF	51 ± 14	48 ± 15	50 ± 15	48 ± 17	51 ± 15	60	.09
Current smoker	105 (19)	68 (27)	23 (18)	6 (19)	2 (18)	0	.17
Previous smoker	263 (47)	103 (41)	66 (50)	15 (47)	5 (45)	1 (33)	.55
Non-smoker	190 (34)	80 (32)	42 (32)	11 (34)	4 (36)	2 (67)	.98
Minnesota residence	385 (69)	182 (73)	94 (72)	25 (78)	6 (55)	3 (100)	.78

Data are presented as average ± standard deviation, or number with percentage shown in parenthesis. A P-value ≤ .05 was considered statistically significant. COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; CVA, cerebrovascular accident; LVEF, left ventricular ejection fraction; NaN, not a number.

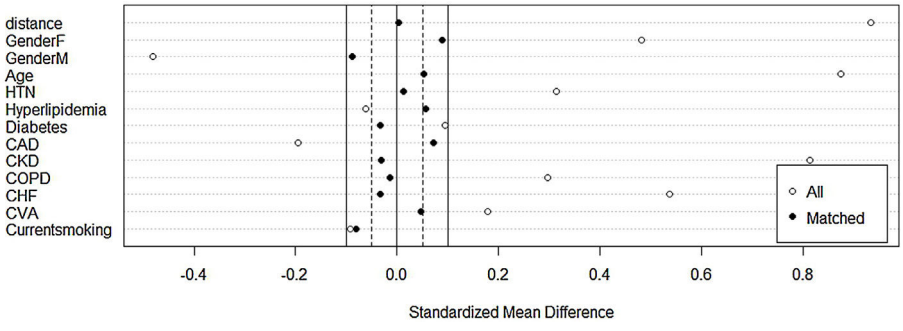

Fig. 4 – Standardized mean difference plot full matching. CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; HTN, hypertension.

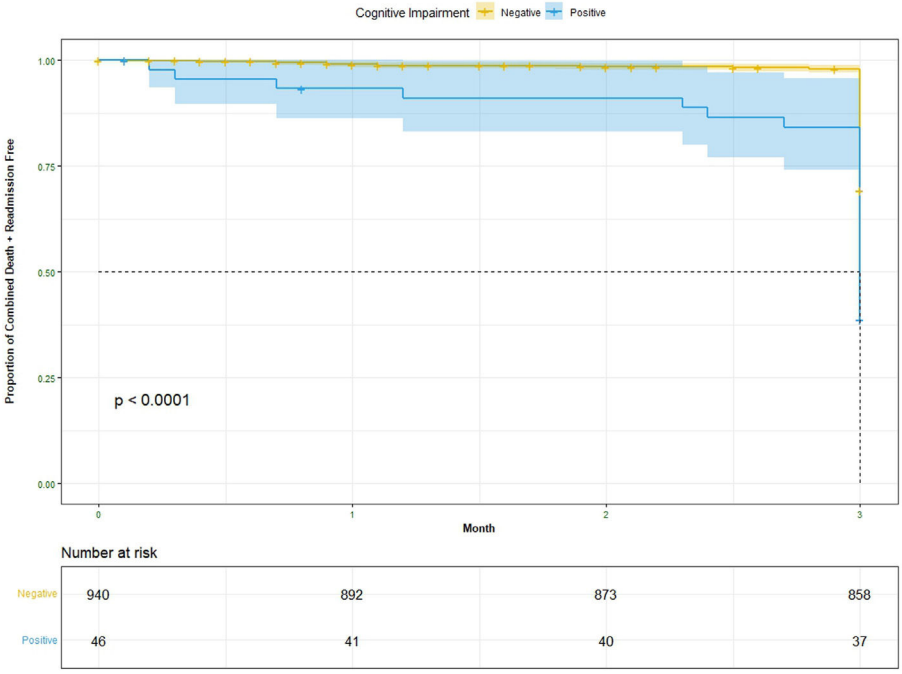

Fig. 5 – Survival at 3-months. A *P*-value ≤ .05 was considered statistically significant.

Table 6 – Outcome data.

Variables	Mini-Cog 5 (*n* = 558)	Mini-Cog 4 (*n* = 251)	Mini-Cog 3 (*n* = 131)	Mini-Cog 2 (*n* = 32)	Mini-Cog 1 (*n* = 11)	Mini-Cog 0 (*n* = 3)	*P*
LOS index admission (days)	5 ± 4	5 ± 4	7 ± 7	7 ± 6	5 ± 3	5 ± 2	< .001
Follow-up duration (months)	12.5 ± 5.1	12.2 ± 5.5	12.4 ± 5.3	11.7 ± 6.4	11.2 ± 7.4	10 ± 1.6	.81
30-Day ED visit	99 (18)	57 (23)	31 (24)	8 (25)	4 (36)	1 (33)	.45
30-Day cardiac readmission	72 (13)	33 (13)	17 (13)	6 (19)	3 (27)	0	.93
30-Day all-cause readmission	88 (16)	42 (17)	26 (20)	8 (25)	4 (36)	0	.58
Cardiac readmission prior to censure	178 (32)	85 (34)	46 (35)	14 (44)	6 (55)	1 (33)	.62
All-cause readmission prior to censure	231 (41)	110 (44)	68 (52)	19 (59)	7 (64)	3 (100)	.08
Death	31 (6)	29 (12)	20 (15)	8 (25)	4 (36)	1 (33)	< .001
Composite outcome	255 (46)	131 (52)	77 (59)	22 (69)	9 (82)	3 (100)	.005

Data are presented as average ± standard deviation, or number with percentage shown in parenthesis. A *P*-value ≤ .05 was considered statistically significant. ED, emergency department; LOS, length of stay.

tional therapist that identified cognitive impairment during their index admission. During the follow-up period 12 (34%) of these patients died and 21 (60%) met the combined end-point of readmission + death.

Finally, we conducted sensitivity analysis for optimal full matching. We used Huber–Maritz *M*-statistics with $\Gamma = 1$ and $P = .0069$, which means the outcome and study conclusion was robust to hidden bias from an unobserved confounder.

Discussion

In our phase I cardiac rehabilitation cohort, poor performance on the Mini-Cog identified an elderly group with significantly increased rates of readmission and death. This poorly performing Mini-Cog group was also found to be an older patient population with multiple co-morbidities.

A positive Mini-Cog was found to be associated with increased absolute levels of death, cardiac readmission and all-cause readmission, with the composite end-point of all-cause readmission + death reaching statistical significance ($P = .05$). Cox proportional hazards model with survival curves found cohort A_1 to have significantly increased readmission + death at 3 months compared to cohort A_2.

These results are consistent with previous publications that have found that cognitive impairment is associated with increased readmission rates and poorer survival in heart failure patients.[8–12] A 2015 study that looked specifically at heart failure patients with a positive Mini-Cog found significantly

increased rates of readmission and death.[9] Interestingly, if the patients were discharged to a long-term care facility then their risk of readmission and death decreased.[8] Another study found cognitive impairment to be an independent predictor of mortality in veterans with heart failure.[14]

The prevalence of 4.6% that we observed in our cohort is a relatively novel finding, as we are unaware of any other publication that evaluated the rate of cognitive impairment in a large, consecutive cardiopulmonary rehabilitation cohort. A 2017 publication from Germany found 36.7% of younger cardiac rehabilitation patients (average age 54.5 years), with a diagnosis of coronary artery disease, had a MoCA score below 26, which was used as the threshold for cognitive impairment.[15] This rate of cognitive impairment is significantly higher than what we observed in our cohort, despite their cohort being significantly younger than ours. A potential explanation for the stark difference in the rate of cognitive impairment between our data and this publication is their use of MoCA to assess for cognitive impairment and our use of the Mini-Cog. The MoCA has been shown to have much lower specificity than the Mini-Mental State Examination (MMSE) for detecting cognitive impairment post-stroke.[16] Interestingly, the MMSE was used as the gold-standard to establish the efficacy of the Mini-Cog for diagnosing cognitive impairment.[5] It is also worth noting that 5% of the German cohort had more severe cognitive impairment, which could potentially be a group more similar to our cohort A_1.[15]

The prevalence of cognitive impairment increased with age in our cohort, with 9.5% of those 70 or older and 12.3% of those 80 and older having a positive Mini-Cog test. This is consistent with previous publications, including a large retrospective series that found 11.6% of patients $\geq$ 75 years of age to have undiagnosed cognitive impairment.[2–5,8–11] Cognitive impairment was uncommon in patients < 70 years of age in our cohort. With consideration of this finding, we have decided to no longer administer the Mini-Cog to phase I cardiopulmonary rehabilitation patients younger than 65 years of age.

The simple incorporation of the Mini-Cog into phase I cardiac rehabilitation provides prognostic information for patients that have a positive assessment. Identifying individuals with cognitive impairment provides an opportunity to intervene, which may slow the progression of their cognitive impairment and improve outcomes. The targets of interventions include reducing alcohol consumption, smoking cessation, treating vascular risk factors, cognitive activities (games, music, reading, etc.), cardiovascular exercise, strength training and even adopting a Mediterranean diet.[17,18] Poor cardiorespiratory fitness is also associated with cognitive dysfunction, with cardiac rehabilitation being associated with improvements in cognition.[19–21] Thus, referral to phase II cardiac rehabilitation will allow them to derive benefit that may improve their cognitive function, in addition to providing the typical benefits of cardiac rehabilitation – improved exercise capacity, improved quality of life, improved cardiovascular risk factor profile, and improved ability to perform activities of daily living.[19–26] Even if these patients are unable to attend all prescribed sessions of cardiac rehab publications have identified the incremental benefit of individual sessions on readmission rates.[27,28] Future retrospective studies could validate our findings in a larger database, while future prospective, randomized studies could evaluate interventions to reduce mortality and morbidity in patients identified as having cognitive impairment on the Mini-Cog assessment.

Limitations

The cohort with a positive Mini-Cog (cohort A_1) is much smaller than the other cohorts, which weakens the strength of our comparisons. While the Mini-Cog test was administered prospectively the data was collected retrospectively. This creates the possibility of selection bias. There were 172 (12%) patients that had incomplete follow-up data. While Care Everywhere records were used to collect information about readmissions occurring outside the HealthPartners system, incomplete readmission data from outside hospitals likely results in an underestimation of the actual readmission rate. We believe that death records for Minnesota residents is accurate, but mortality for Wisconsin residents, as well as the small percentage of patients from outside Minnesota or Wisconsin (2%), is likely an underestimation. We do not have specific information on each patient's Mini-Cog assessment, only the composite score.

Conclusions

The Mini-Cog assessment can be incorporated into an inpatient cardiac rehabilitation program and will identify cognitive impairment in approximately 10% of those $\geq$70 years of age. Poor performance on the Mini-Cog identified an older group with multiple co-morbidities that had significantly increased rates of readmission and death at 3-months follow-up.

What is known about the subject?

- The Mini-Cog test is a quick and effective tool for identifying cognitive dysfunction.
- Cognitive impairment is common in patients with heart failure.
- A positive Mini-Cog was associated with increased rates of readmission and death in a heart failure cohort.

Does it contribute anything new?

- This is the first publication to incorporate the mini-cog mental examination into a phase I cardiac rehabilitation program.
- We found 5% of our study population to have a positive mini-cog, consistent with cognitive impairment, including 10% of patients 70 years of age or older.
- The group with a positive Mini-Cog had significantly increased readmission or death at 3 months.

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Authors' contribution

C. House collected data, analyzed data, and drafted the manuscript; H. Dang performed the statistical analysis; K. Moriarty critically revised the manuscript; W. Nelson conceptualized the study and critically revised the manuscript. All authors revised and accepted the manuscript.

Conflicts of interest

The authors declare that there is no conflict of interest.

REFERENCES

1. Solomon PR, Murphy CA. Should we screen for Alzheimer's disease? A review of the evidence for and against screening Alzheimer's disease in primary care practice. *Geriatrics*. 2005;60:26–31.
2. Fogg C, Meredith P, Bridges J, et al. The relationship between cognitive impairment, mortality and discharge characteristics in a large cohort of older adults with unscheduled admissions to an acute hospital: a retrospective observational study. *Age Ageing*. 2017;46:794–801.
3. Fogg C, Meredith P, Culliford D, et al. Cognitive impairment is independently associated with mortality, extended hospital stays and early readmission of older people with emergency hospitalizations: a retrospective cohort study. *Int J Nurs Stud*. 2019;96:1–8.
4. Heng M, Eagen CE, Javeden H, et al. Abnormal mini-cog is associated with higher risk of complications and delirium in geriatric patients with fracture. *J Bone Joint Surg Am*. 2016;98:742–750.
5. Borson S, Scanlan JM, Chen P, et al. The Mini-Cog as a screen for dementia: validation in a population-based sample. *J Am Geriatr Soc*. 2003;51:1451–1454.
6. Ketterer MW, Chawa M, Paone G. Prospective correlates of early (30 day) readmissions on a cardiothoracic surgery service. *Psychol Health Med*. 2017;22:947–954.
7. Briet C, Blanchart K, Lemaître A, et al. Bedside mental status and outcome in elderly patients admitted for acute coronary syndromes. *Heart*. 2019;105:1635–1641.
8. Saito H, Yamashita M, Endo Y, et al. Cognitive impairment measured by Mini-Cog provides additive prognostic information in elderly patients with heart failure. *J Cardiol*. 2020;76:350–356.
9. Patel A, Parikh R, Howell EH, et al. Mini-Cog performance: novel marker of post discharge risk among patients hospitalized for heart failure. *Circ Heart Fail*. 2015;8:8–16.
10. Agarwal KS, Kazim R, Xu J, et al. Unrecognized cognitive impairment and its effect on heart failure readmissions of elderly patients. *J Am Geriatr Soc*. 2016;64:2296–2301.
11. Dodson JA, Truong TT, Towle VR, et al. Cognitive impairment in older adults with heart failure: prevalence, documentation, and impact on outcomes. *Am J Med*. 2013;126:120–126.
12. Chaudhry SI, Wang Y, Gill TM, et al. Geriatric conditions and subsequent mortality in older patients with heart failure. *J Am Coll Cardiol*. 2010;55:309–316.
13. Ho DE, Imai K, King G, et al. MatchIt: nonparametric preprocessing for parametric causal inference. *J Stat Softw*. 2011;42:1–28.
14. Lan H, Hawkins LA, Kashner M, et al. Cognitive impairment predicts mortality in outpatient veterans with heart failure. *Heart Lung*. 2018;47:546–552.
15. Salzwedel A, Heidler M-D, Haubold K, et al. Prevalence of mild cognitive impairment in employable patients after acute coronary event in cardiac rehabilitation. *Vasc Health Risk Manag*. 2017;13:55–60.
16. Godefroy O, Fickl A, Roussel M, et al. Is the Montreal Cognitive Assessment superior to the Mini-Mental State Examination to detect post-stroke cognitive impairment? A study with neuropsychological evaluation. *Stroke*. 2011;42:1712–1716.
17. Eshkoor SA, Hamid TA, Mun CY, et al. Mild cognitive impairment and its management in older people. *Clin Interv Ageing*. 2015;10:687–693.
18. Mavros Y, Gates N, Wilson GC, et al. Mediation of cognitive function improvements by strength gains after resistance training in older adults with mild cognitive impairment: outcomes of the study of mental and resistance training. *J Am Geriatr Soc*. 2017;65:550–559.
19. Stanek KM, Gunstad J, Spitznagel MB, et al. Improvements in cognitive function following cardiac rehabilitation for older adults with cardiovascular disease. *Int J Neurosci*. 2011;121:86–93.
20. Alosco ML, Spitznagel MB, Cohen R, et al. Cardiac rehabilitation is associated with lasting improvements in cognitive function in older adults with heart failure. *Acta Cardiol*. 2014;69:407–414.
21. Fujiyoshi K, Minami Y, Yamaoka-Tojo M, et al. Effect of cardiac rehabilitation on cognitive function in elderly patients with cardiovascular diseases. *PLOS ONE*. 2020;15:e0233688.
22. Lavie C, Milani R, Littman A. Benefits of cardiac rehabilitation and exercise training in secondary coronary prevention in the elderly. *J Am Coll Cardiol*. 1993;22:678–683.
23. Taylor RS, Walker S, Smart NA, et al. Impact of exercise rehabilitation on exercise capacity and quality-of-life in heart failure: individual participation meta-analysis. *J Am Coll Cardiol*. 2019;73:1430–1443.
24. Alfaraidhy MA, Regan C, Forman DE. Cardiac rehabilitation for older adults: current evidence and future potential. *Expert Rev Cardiovasc Ther*. 2022;20:13–34.
25. Lavie CJ, Arena R, Franklin BA. Cardiac rehabilitation and healthy life-style interventions rectifying program deficiencies to improve patient outcomes. *J Am Coll Cardiol*. 2016;67:13–15.
26. Sandesara PB, Lambert CT, Gordon NF, et al. Cardiac rehabilitation and risk reduction time to "rebrand and reinvigorate". *J Am Coll Cardiol*. 2015;65:389–395.
27. House CM, Anstadt MA, Stuck LH, et al. The association of cardiac rehabilitation attendance and hospital readmission. *Am J Lifestyle Med*. 2016;12:513–520.
28. Medina-Inojosa JR, Grace SL, Supervia M, et al. Dose of cardiac rehabilitation to reduce mortality and morbidity: a population-based study. *J Am Heart Assoc*. 2021;10:e021356.