Health Literacy and Risk Factors for Coronary Artery Disease (From the CONCARD^{PCI} Study)

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In the setting of established coronary artery disease (CAD), lower health literacy is associated with poor outcomes. The aim of this study was to determine whether health literacy at the index admission was associated with established CAD risk factors and with changes in CAD risk factors from baseline until 6 months after percutaneous coronary intervention (PCI). A multicenter cohort study recruited 3,417 patients aged ≥18 years who were treated with PCI. Assessments were made at the index admission for PCI and at 6-month follow-up, including 4 of the 9 scales from the Health Literacy Questionnaire, an assessment of behavioral risk factors and psychologic risk factors for CAD. In this large study, key aspects of health literacy were associated with behavioral and psychologic risk factors for CAD. For each 1-unit higher score on the health literacy scales, weekly physical activity was 12 to 20 intensity-adjusted minutes higher, and the odds of being a nonsmoker were 24% to 72% higher. The risk factors for CAD improved from baseline to 6-month follow-up, although most were not significantly associated with health literacy. Still, patients with lower health literacy scores were more likely to report a greater reduction in depression symptoms from baseline to 6-month follow-up. In conclusion, the study provides evidence that several aspects of health literacy are associated with risk factors for CAD. These results serve as a reminder to healthcare teams to consider health literacy challenges in connection with secondary prevention care. **(Am J Cardiol 2022;179:22−30)**

Introduction

The health literacy of an individual represents the knowledge, confidence, and comfort to access, understand, appraise, remember, and use information about health.[1] Because low health literacy has been shown to be common among patients with coronary artery disease (CAD),[2] the American Heart Association (AHA) has addressed future directions for integrating health literacy in research with the goal of improving patient health.[3,4] In addition to clinical conditions affecting cardiovascular risk, CAD is predominantly the result of behavioral risk factors.[4,5] There has also been a growing consensus that depression and anxiety should be considered as modifiable prognostic risk factors for CAD.[5−7] Low health literacy has been associated with various social determinants of health,[8] affecting patients' ability to take health-related decisions.[4] A lower level of health literacy has been associated with physical inactivity,[9,10] a higher body mass index (BMI),[9−11] and higher anxiety level.[11] However, none of the previous studies determined the associations between broader contemporary aspects of health literacy and risk factors for CAD before and after percutaneous coronary intervention (PCI). To fill this knowledge gap, this study aimed to determine whether health literacy at the index admission was associated with established CAD risk factors and with changes in CAD risk factors from baseline until 6 months after PCI.

Methods

The CONCARD^{PCI} study is an interdisciplinary, multicenter, prospective cohort study. It uses a combination of data from hospital medical records and patient self-reports to identify novel pathways for follow-up care that

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Funding: None.

See page 29 for disclosure information.

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contribute to improved outcomes in patients with CAD.[12] All adult patients undergoing PCI at 7 large referral PCI centers in Norway and Denmark were prospectively screened for eligibility from June 2017 to May 2019. Inclusion criteria were age ≥18 years and living at home at the time of inclusion. Exclusion criteria were inability to speak Norwegian/Danish or to complete the questionnaires, PCI without stent implantation, and PCI-related to transcatheter aortic or mitral valve implantation. The CONCARD^{PCI}-study was approved by the Norwegian Regional Committee for Ethics in Medical Research (REK 2015/57) and by the Data Protection Agency in the Zealand region for the Danish centers (REG-145-2017). The study complied with the ethical principles outlined in the Declaration of Helsinki.

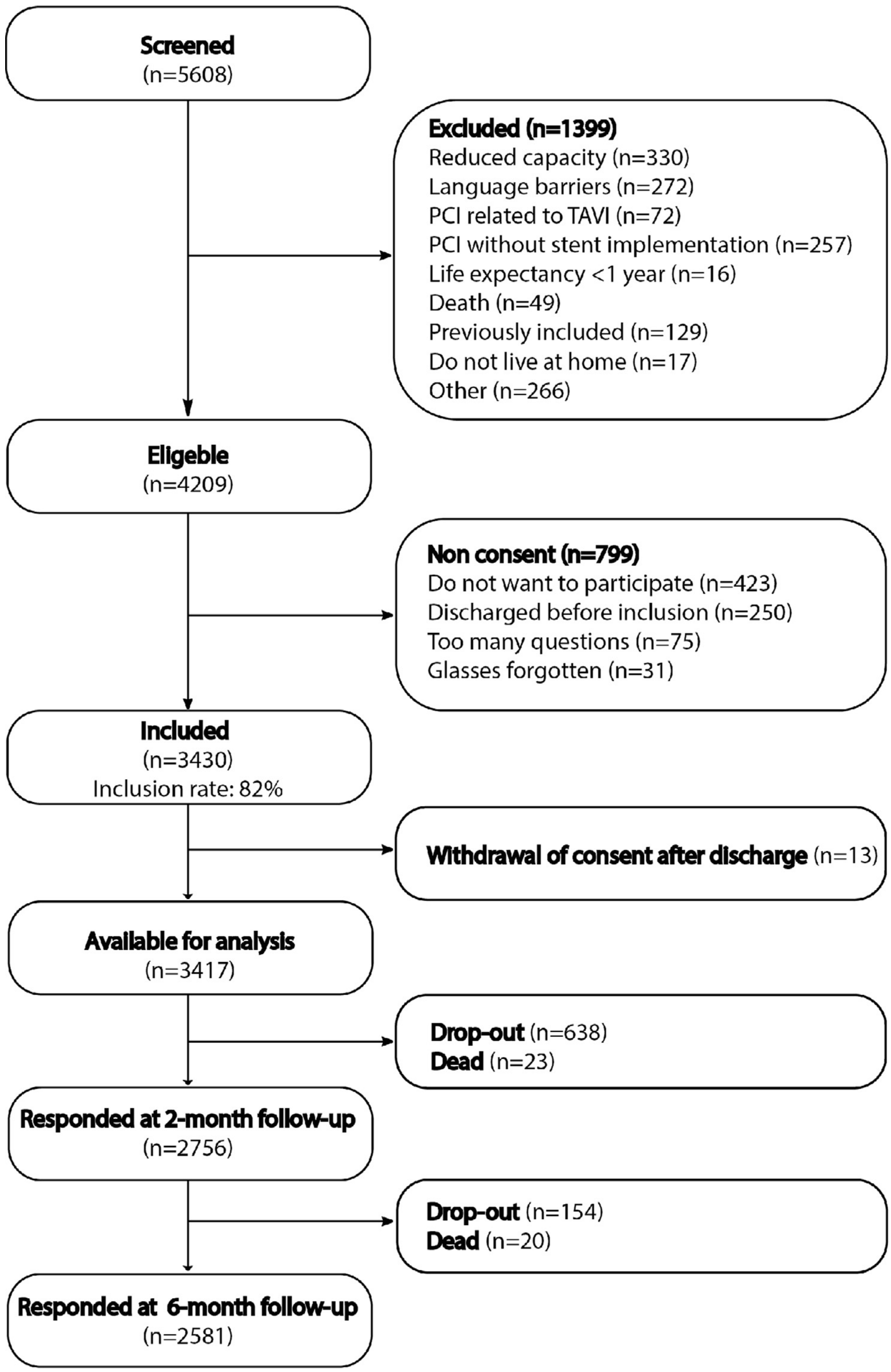

Figure 1. The flow chart describing the participant enrollment and selection procedure of the CONCARD^{PCI} study with detailed information about the exclusions and discontinuations during the 6-month follow-up of the study.

Self-reported health literacy, risk factors for CAD, and sociodemographic data were collected at baseline during index hospitalization. Details about clinical characteristics were collected from patient medical records. All patients were followed up with postal or electronic self-report questionnaires assessing changes in risk factors for CAD (physical activity, smoking, anxiety, and depression) at the 6-month follow-up.

Sociodemographic data included age, gender, cohabitation, education level, and work status. Clinical data included medical history.

Elements of health literacy were measured using 4 of the 9 scales of the Health Literacy Questionnaire (HLQ).[13] The scales chosen assessed the perspective of patients' knowledge and confidence to access ("ability to find good information"), understand ("understanding health information well enough to know what to do"), and appraise information ("appraisal of health information"). Additionally, the scale "social support for health" reflected extrinsic dimensions of health literacy (e.g., patients' social interactions related to the health care system), important for overcoming challenges associated with accessing, understanding, and using health information. A low HLQ score indicates that the respondent has difficulties within the scale.

Behavioral risk factors for CAD included smoking status (current smoker or nonsmoker), BMI, and physical activity during leisure time. To assess engagement in regular physical activity (walking, skiing, swimming, and working out/sports) the physical activity frequency, intensity, and duration questionnaire was used.[14,15] Symptoms of anxiety and depression were measured using the hospital anxiety and depression Scale (HADS).[16] For all instruments, details on computation of scores are stated in Supplementary material.

Descriptive analyses were presented as percentages or counts for categorical variables, and as means and standard deviations for continuous variables. BMI, intensity-adjusted weekly physical activity, and HADS were analyzed descriptively as both continuous and categoric variables. To compare the differences in HLQ scales between subgroups, *t*-tests and one-way analysis of variance were used. Changes in the intensity-adjusted weekly physical activity score, smoking status, anxiety, and depression (HADS-anxiety[A] and HADS-depression[D]) from baseline to 6 months were analyzed using Kappa statistics or paired-samples *t*-tests, as appropriate.

To estimate the associations of health literacy with BMI, the intensity-adjusted weekly physical activity score, HADS-A, and HADS-D at the index admission for PCI, respectively, unadjusted and adjusted linear regression models were used. To estimate whether health literacy was associated with the dichotomous outcome of smoking status, unadjusted and adjusted logistic regression models were used. Because sociodemographic factors, such as age, education, and gender, have been shown to be associated with management and control of modifiable risk factors for CAD,[17] the regression analyses were performed with increasing covariate adjustments. The models used were: model 1: unadjusted; model 2: adjusted for age, education, and gender; model 3: model 2 plus previous diagnosis of CAD, peripheral artery disease, atrial fibrillation, chronic

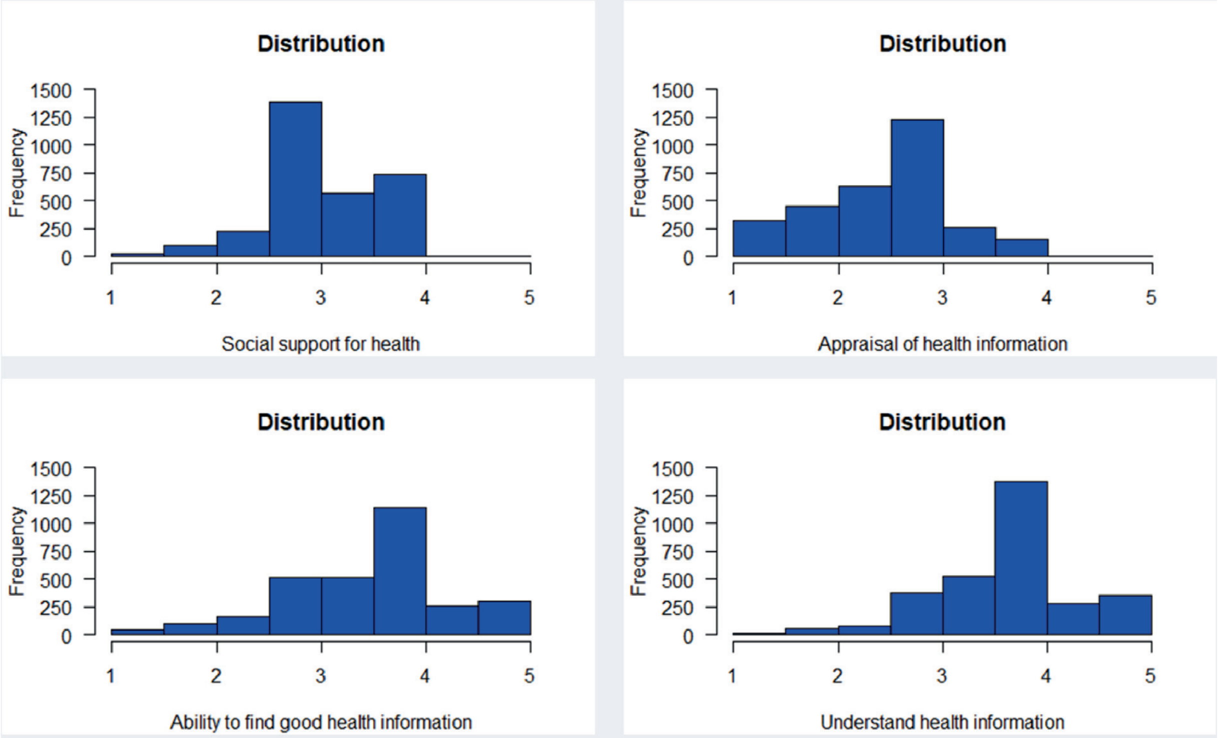

Figure 2. Distribution of the 4 HLQ scales for the overall sample (n = 3,417). Social support for health score range: 1 to 4, Appraisal of health information score range: 1 to 4, Ability to find good health information score range: 1 to 5, Understand health information score range: 1 to 5.

renal disease, diabetes, hypercholesterolemia, and hypertension. Additionally, for analyses, including HADS-A and HADS-D, model 3 was adjusted for a medical history of anxiety and depression.

Mixed effects models were used to estimate the changes in the calculated intensity-adjusted weekly physical activity score, HADS-A, and HADS-D from baseline to 6-month follow-up. Mixed effects models were used to estimate whether baseline health literacy levels were associated with changes in risk factors for CAD over time. Time was included as a categoric variable (baseline vs 6 months) and a random effect was included for patient variations. Relations with changes over time are shown as interactions with time. The mixed effects models adjust for dependency of observations within participants and allow for imbalance between baseline and 6-month follow-up, for instance by allowing different regression coefficients over time within 1 subject. Thus, participants who only answered the questions at baseline and not at 6-month follow-up still contributed information to the model.[18] Changes in smoking status from baseline to the 6-month follow-up and whether changes were associated with baseline health literacy levels were investigated by logistic regression using generalized estimation equations, with an exchangeable correlation structure to account for within-person clustering. Each of these models was adjusted for age, gender, and education level.

SPSS (IBM SPSS Statistics for Windows, Version 24.0. Armonk, New York) was used for descriptive statistics and linear regression, whereas the R (The R Foundation for Statistical Computing, Vienna, Austria) packages nlme and gee were used for mixed effects models and logistic regression with generalized estimation equations, respectively.

Results

In total, 3,417 patients were included in the study (Figure 1). The characteristics and the health literacy level of the patients at the index admission for PCI are presented in Figure 2 and Table 1. Overall, patients with a higher health literacy score were younger, had a higher level of education, and more often cohabitating. Men had higher scores than women on 3 of the 4 scales (Supplementary Table 1). Behavioral and psychologic risk factors for CAD are shown in Table 2.

The associations between the health literacy scales and behavioral and psychologic risk factors for CAD at the index admission for PCI are presented in Table 3. The health literacy scales "ability to find good health information" and "understanding health information well enough to know what to do" were significantly negatively associated with BMI. All the health literacy scales were significantly associated with the intensity-adjusted physical activity score, so that, for a 1-unit higher score on each health literacy scale, the estimated weekly physical activity was 12 to 20 intensity-adjusted minutes higher. Furthermore, the fully adjusted model indicated that the 4 aspects of health literacy were associated with being a nonsmoker: for each 1-unit higher score on the health literacy scales, the odds of being a nonsmoker were 24% ("appraisal of health information") to 72% higher ("social support for health"). Furthermore, for each 1-unit higher score for "social support for health", "ability to find health information", and "understand health information well enough to know what to do", the HADS-D score was from 1 to 1.6 point lower. Similarly, 3 aspects of health literacy were significantly associated with the HADS-A scale, meaning that for each 1-unit higher score on the health literacy scales, the HADS-A score was 0.85 ("ability to find health information") to 1.24 ("social support for health") points lower. Conversely, for each 1-unit higher score for "appraisal of health information", the HADS-A score was 0.23 points higher (Table 3).

The estimated weekly physical activity score increased by 28 intensity-adjusted minutes from baseline to 6-month follow-up, and adherence to physical activity recommendations increased from 24% to 33%. Further, the proportion of nonsmokers increased during follow-up. Finally, anxiety and depression scores decreased from baseline to 6 months (Table 2).

In the mixed effects model, none of the 4 health literacy scales were significantly associated with the change in the calculated intensity-adjusted physical activity score or

Table 1
Demographic and clinical risk factors of patients at the index admission for percutaneous coronary intervention

Variable	Total (n=3417)
Age (year) (mean±SD)	65.6 (0.9)
Male	2671 (78%)
Female	746 (22%)
Danish/ Norwegian	2824 (92%)
Born in Denmark/Norway	114 (5%)
Immigrant	135 (4%)
Cohabitating	2326 (76%)
Living alone	747 (24%)
Education level	
Primary school	639 (20%)
Vocational school	1374 (43%)
High School	298 (9%)
College/University less than 4 years	485 (15%)
College/University 4 years or more	380 (12%)
Employment status	
Working	1246 (39%)
Retired	1615 (51%)
Other	338 (11%)
Medical history	
Anxiety and/or depression	382 (11%)
Atrial fibrillation	408 (12%)
Chronic renal disease	156 (5%)
Coronary artery disease	1223 (36%)
Diabetes	598 (18%)
Hypercholesterolemia	1568 (46%)
Hypertension	1773 (52%)
Percutaneous coronary intervention indication	
Elective percutaneous coronary intervention	1317 (39%)
Non-ST-segment elevation myocardial infarction/Unstable angina pectoris	1351 (40%)
ST-segment elevation myocardial infarction	740 (22%)
Health literacy	
Social support for health (mean±SD)	3.0 (0.5)
Appraisal of health information (mean±SD)	2.5 (0.7)
Ability to find good health information (mean±SD)	3.5 (0.8)
Understanding health information (mean±SD)	3.7 (0.7)

Table 2
Behavioral and psychological risk factors for coronary artery disease at the index admission for percutaneous coronary intervention, and adjusted estimated changes in physical activity, smoking status, anxiety and depression from baseline to 6 months follow-up

Variable	Baseline	6 months	Estimate (95% CI)*	OR (95% CI)*	p-value	Cohen's Kappa (95% CI)
BMI (kg/m²) (mean±SD)	27.7 (4.5)					
<18.5	22 (1%)					
18.5-24.9	937 (28%)					
25- 29.9	1534 (45%)					
≥30	884 (26%)					
Physical activity (mean±SD)†	103 (114)	133 (124)	28 (23; 32)		<0.001	
Adherence to physical activity recommendation ‡						
Yes	742 (24%)	803 (32.5%)		1.48 (1.34;1.63)	<0.001	0.426 (0.387;0.465)
No	2330 (76%)	1664 (67.5%)				
Smoking status						
Current smoker	529 (17%)	247 (10%)		1.66 (1.49;1.86)	<0.001	0.585 (0.536;0.634)
Nonsmoker	2655 (83)	2291 (90%)				
HADS-T score (mean±SD)	8.43 (6.6)	6.26 (6.2)	-1.91 (-2.13;-1.70)		<0.001	
HADS-A score (mean±SD)	4.97 (3.9)	3.49 (3.5)	-1.35 (-1.48;1.22)		<0.001	
<8	2423 (76%)	2167 (86%)			<0.001	0.323 (0.283;0.362)
8 - <11	447 (14%)	245 (10%)				
≥11	323 (10%)	122 (5%)				
HADS-D score (mean±SD)	3.46 (3.3)	2.78 (3.1)	-0.57 (-0.69;-0.46)		<0.001	
<8	2753 (86%)	2280 (90%)			<0.001	0.315 (0.266; 0.364)
8 - <11	310 (10%)	180 (7%)				
≥11	128 (4%)	77 (3%)				

BMI = body mass index; CI = Confidence interval; HADS-A = hospital anxiety and depression scale anxiety; HADS-D = hospital anxiety and depression scale depression; HADS-T = Hospital anxiety and depression scale total; OR = Odds ratio; SD = standard deviation.

* The models are adjusted for age, gender, and education level.

† Calculated intensity-adjusted weekly physical activity score (Scale 0 to 750).

‡ Adherent or nonadherent to physical activity recommendations according to a cutoff of 150 min/wk of moderate physical activity or alternatively 75 minutes of high intensity exercise.

smoking status from baseline to 6-month follow-up (Supplementary Tables 2 and 3). However, patients with lower scores for “social support for health”, “ability to find good health information”, and “understanding health information well enough to know what to do” were more likely to have a greater decrease in their HADS-D score from baseline to 6-month follow-up. However, this subpopulation had a higher score for depression symptoms at baseline, which was also sustained at 6-month follow-up (Figure 3 and Supplementary Table 2). Patients with a higher level for “appraisal of health information” were more likely to have a greater reduction in HADS-A (Figure 3and Supplementary Table 2). The aspects of health literacy were not significantly associated with changes in behavioral risk factors for CAD. Factors associated with missing data at 6 months are presented in Supplementary Table 4.

Discussion

In this large study of patients attending routine coronary care, lower scores for the 4 aspects of health literacy were significantly associated with being a smoker, having a lower physical activity level, and a higher burden of depression and anxiety. Furthermore, a higher BMI was significantly associated with lower “ability to find health information” and “understanding health information well enough to know what to do”. There was a significant improvement in physical activity and smoking cessation, but these changes were not significantly associated with health literacy. Patients with a lower health literacy score at baseline had a higher burden of depression symptoms but less depression symptoms from baseline to 6-month follow-up. This underpins the need for increased availability of secondary prevention programs, such as eHealth technologies, which can provide easier access to health information and educational materials, including support for physical activity, smoking cessation, and psychologic management.[19]

Lower health literacy was significantly associated with a higher burden of both anxiety and depression at the index admission for PCI. No other studies have determined an association between health literacy and anxiety and depression symptoms in patients with CAD. However, a study of patients with heart failure reported that patients with higher levels of depression had lower health literacy, which impacted their self-care behaviors.[20] Another study of patients with chronic kidney disease reported that having more depressive symptoms was negatively associated with health literacy.[21] Because it is well known that depression is associated with an increased risk of a poorer clinical outcome in patients after PCI,[22] these results suggest that it is prudent to focus on health literacy in secondary prevention care for patients with depression and anxiety symptoms after PCI. Additionally, there was a significant improvement in depression and anxiety symptoms from baseline to 6-month follow-up and a significant association between health literacy and the changes in depression symptoms over this period. These associations indicated that the health literacy scale “appraisal of health information” was weakly

Table 3
Unadjusted and adjusted association between health literacy, BMI, physical activity, HADS and nonsmoking status at baseline

	BMI		Physical activity*		HADS-A		HADS-D		Nonsmoking status†	
	Coef.(95% CI)	p-value	Coef. (95% CI)	p-value	Coef.(95% CI)	p-value	Coef.(95% CI)	p-value	OR (95% CI)	p-value
Social support for health										
Model 1	-0.41 (-0.70;-0.12)	0.006	22.81 (15.24;30.39)	<0.001	-1.32 (-1.57;-1.06)	<0.001	-1.78 (-1.99;-1.58)	<0.001	1.61 (1.36;1.91)	<0.001
Model 2	-0.27 (-0.56;0.012)	0.060	20.55 (12.90;28.19)	<0.001	-1.34 (-1.59;-1.10)	<0.001	-1.77 (-1.98;-1.56)	<0.001	1.63 (1.36;1.95)	<0.001
Model 3	-0.17 (-0.45;0.12)	0.252	19.68 (11.85;27.50)	<0.001	-1.24 (-1.49;-0.99)	<0.001	-1.64 (-1.84;-1.43)	<0.001	1.72 (1.43;2.07)	<0.001
Appraisal of health information										
Model 1	-0.01 (-0.25;0.22)	0.905	14.22 (8.03;20.40)	<0.001	0.20 (-0.01;0.40)	0.063	-0.19 (-.036;-0.01)	0.038	1.28 (1.12;1.47)	<0.001
Model 2	-0.03 (-0.26;0.20)	0.814	11.80 (5.58;18.02)	<0.001	0.22 (0.01;0.42)	0.036	-0.15 (-0.32;0.03)	0.108		0.002
Model 3	-0.10 (-0.33;0.13)	0.392	11.96 (5.61;18.30)	<0.001	0.22 (0.01;0.42)	0.038	-0.17 (-0.35;0.01)	0.060	1.24 (1.06;1.44)	0.007
Ability to find good health information										
Model 1	-0.10 (-0.31;0.10)	0.330	21.73 (16.42;27.04)	<0.001	-0.77 (-0.95;-0.59)	<0.001	-0.98 (-1.13;-0.83)	<0.001	1.32 (1.17;1.48)	<0.001
Model 2	-0.22 (-0.44;-0.01)	0.040	17.10 (11.35;22.85)	<0.001	-0.87 (-1.06;-0.68)	<0.001	-1.03 (-1.19;-0.88)	<0.001	1.37 (1.20;1.57)	<0.001
Model 3	-0.26 (-0.47;-0.05)	0.016	16.95 (11.08;22.83)	<0.001	-0.85 (-1.04;-0.66)	<0.001	-0.99 (-1.15;-0.83)	<0.001	1.38 (1.20;1.58)	<0.001
Understand health information										
Model 1	-0.36 (-0.60;-0.12)	0.003	26.04 (19.80;32.28)	<0.001	-1.11 (-1.32;-0.90)	<0.001	-1.19 (-1.37;-1.02)	<0.001	1.49 (1.29;1.72)	<0.001
Model 2	-0.40 (-0.64;-0.15)	0.001	20.51 (13.89;27.14)	<0.001	-1.12 (-1.34;-0.91)	<0.001	-1.22 (-1.40;-1.04)	<0.001	1.47 (1.25;1.72)	<0.001
Model 3	-0.38 (-0.62;-0.14)	0.002	19.64 (12.89;26.40)	<0.001	-1.13 (-1.34;-0.91)	<0.001	-1.13 (-1.34;0.92)	<0.001	1.51 (1.28;1.77)	<0.001

BMI = body mass index; CI = Confidence interval; Coef = coefficient; HADS-A = hospital anxiety and depression scale anxiety; HADS-D = hospital anxiety and depression scale depression; OR = Odds ratio.

Model 1. unadjusted. Model 2: adjusted for age, gender, education level. Model 3: Model 2 plus medical history of CAD, periphery artery disease, atrial fibrillation, chronic renal disease, diabetes, hypercholesterolemia, and hypertension. Additionally, for analysis including HADS; Model 3 was adjusted for medical history of anxiety and depression.

* Calculated intensity-adjusted weekly physical activity score (Scale 0 to 750).

† Logistic regression.

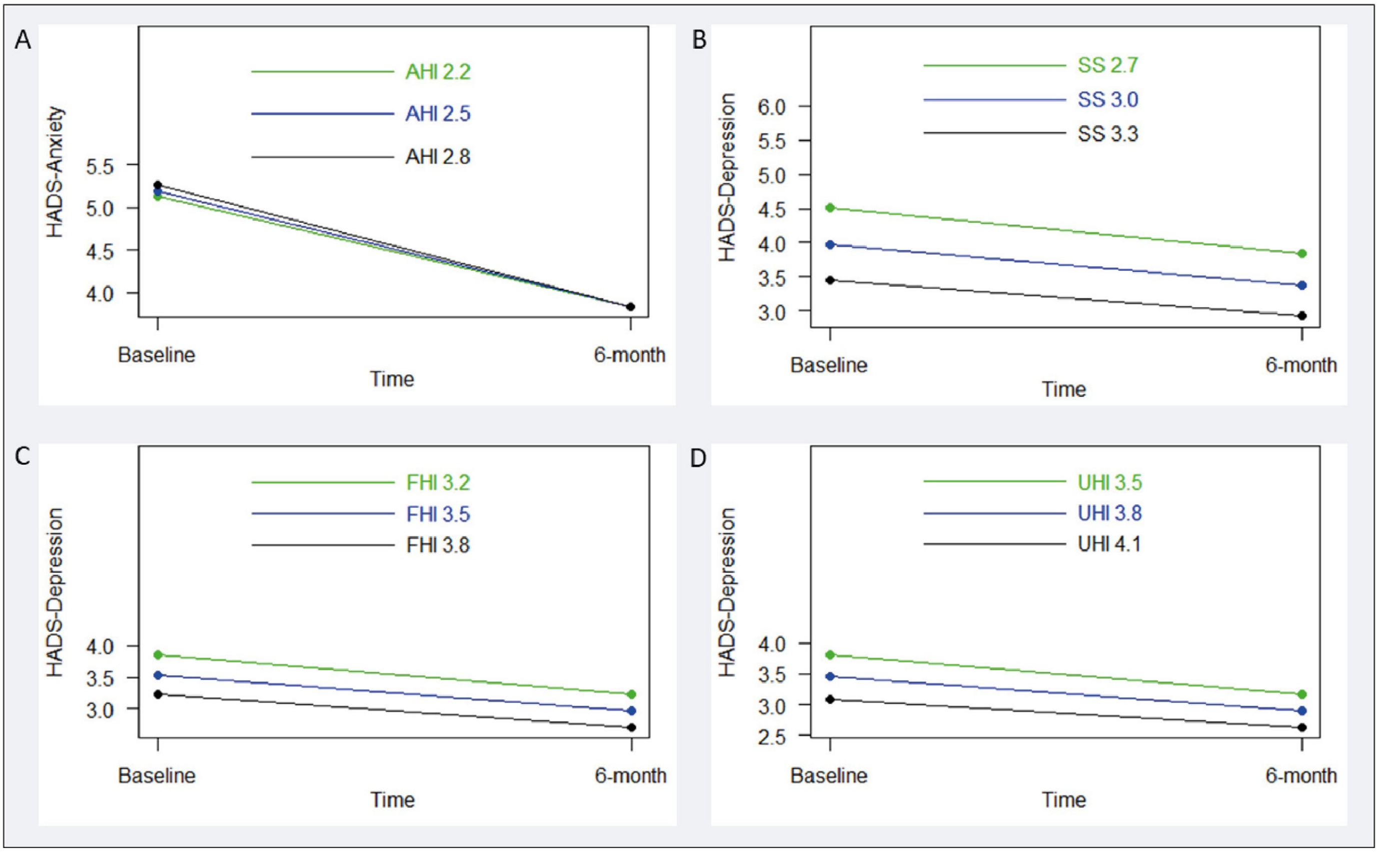

Figure 3. Mixed effect models estimating the association of health literacy levels at the index admission on changes in HADS-anxiety and HADS-depression from baseline to 6 months follow-up. Reference: 66-year-old, male, education level primary school. AHI = Appraisal of health information; FHI = Ability to find good health information; SS = Social support for health; UHI = Understand health information well enough to know what to do.

associated with the reduction in anxiety but not with depression symptoms after PCI. However, these associations were small and may be related to the higher burden of symptoms at baseline.

Patients with lower health literacy were more likely to be less physically active at the index admission for PCI. A 1-unit higher mean scale score for “understand health information well enough to know what to do” has previously been shown to be associated with being physically inactive.[9] Similarly, a Scottish study that examined 5 distinct health literacy profiles in a cardiac rehabilitation setting reported that people with a range of lower health literacy profiles tended to be physically inactive.[10] Moreover, although the degree of association between health literacy and BMI and smoking differ in previous studies, our study found that patients with lower health literacy were more likely to have a higher BMI and to be smokers. These results are in line with the AHA scientific statement, which states that health literacy is associated with a healthier lifestyle and favorable behaviors.[3] However, the diverse questionnaires used in previous studies limit the opportunity to compare the results.

There was a significant improvement in physical activity and smoking cessation at the 6-month follow-up, but these changes were not significantly associated with the aspects of health literacy. This result corresponds with another longitudinal study showing a nonsignificant association between health literacy and changes in lifestyle at 6-month follow-up.[23] This may relate to the short follow-up period or that, after PCI, patients were motivated and determined to increase physical activity and smoking cessation, irrespective of their health literacy.[24] It is important to emphasize the low proportion adhering to the physical activity recommendations. Although the increase was 50% during follow-up, approximately 2 in every 3 participants were not following the recommendations. Further, only a minority of participants smoked at baseline, and the proportion of smokers decreased during follow-up. For many patients, there already is ample information and support to stop smoking, and it is possible that the specific health literacy scales were not the ones that are most relevant to patients in this setting regarding smoking cessation.

This study has both strengths and limitations. First, the study is timely given that the AHA scientific statement on health literacy calls for studies determining the associations between health literacy and CAD.[3] Second, the cohort design with patient involvement and the use of standardized patient-reported outcome measures, combined with data abstracted from medical records, are robust features of CONCARD^{PCI}.[12] Third, the large sample size provides adequate power for the analyses. The study had a high inclusion rate (82%). Although 25% of patients did not respond the outcome questionnaires at 6-month follow-up, there were no significant associations between health literacy, anxiety, or depression at baseline and whether the patients answered the questions or not (Supplementary Table 4).

However, smoking status and intensity of physical activity were significantly associated with missingness, and there may be unmeasurable nonresponse bias for these outcomes. A strength of this study is that we used a measure of health literacy designed to detect change in outcomes (the HLQ). However, to reduce respondent burden only 4 of 9 HLQ scales were used. The other scales may have provided insights, such as skills related to actively managing health, relations with healthcare providers, or ability to navigate the healthcare system.[13] Notwithstanding the complexity of health literacy, the scales we included cover pertinent aspects of health literacy, reflecting competencies for participation in the health care process. Health literacy was only measured at the index admission for PCI. Because health literacy is dynamic,[25] it is possible that it changed during follow-up, leading to further changes in CAD risk factors. Finally, the generalizability of the results may be limited to high-income countries and/or settings with universal health coverage; therefore, further work is needed across diverse health systems.

In conclusion, in a population of patients treated with PCI, there was evidence that health literacy was associated with behavioral and psychologic risk factors at the index admission for PCI. Behavioral and psychologic risk factors for CAD control improved from baseline to 6-month follow-up, mostly without significant associations with health literacy. However, most patients did not follow the recommendations for physical activity. Lastly, there was evidence that health literacy was associated with changes in anxiety and depression symptoms at the 6-month follow-up. Strategies for secondary prevention that address barriers to improving modifiable risk factors due to limited health literacy are pivotal in reducing the risk of future CAD events.

Acknowledgment

The authors thank Marie Hayes for development of the graphical abstract.

Disclosures

The authors have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2022.06.016.

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