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Health literacy and 1-year mortality: Mechanisms of association among adults hospitalized for cardiovascular disease

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Abstract

Objective: To test theorized patient-level mediators in the causal pathway between health literacy (HL) and 1-year mortality among adults with cardiovascular disease (CVD)

Patients and Methods: 3,000 adults treated at Vanderbilt University Hospital from October 11, 2011 to December 18, 2015 for acute coronary syndrome or acute decompensated heart failure (ADHF) participated in the Vanderbilt Inpatient Cohort Study. Participants completed a bed-side administered survey and consented to health record review and longitudinal follow-up. Multivariable mediation models examined the direct and indirect effects of HL (a latent variable with 4 indicators) with 1-year mortality post-discharge (dichotomous). Hypothesized mediators

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included social support, health competence, health behavior, comorbidity index, type of CVD diagnosis, and prior year hospitalizations.

Results: Of the 2,977 patients discharged from the hospital (60% male, mean age 61 years, 83% non-Hispanic White, 37% admitted for ADHF), 17–23% had inadequate HL depending on measure, and 10% died within 1 year. The total effect of lower HL on 1-year mortality (AOR=1.31 [95% CI, 1.01, 1.69]) was decomposed into an indirect effect (AOR=1.50 [1.35, 1.67]) via the mediators and a nonsignificant direct effect (AOR=0.87 [CI, 0.66, 1.14]). Each standard deviation decrease in HL was associated with an absolute 3.2 percentage point increase in the probability of 1-year mortality via mediators admitted for ADHF, comorbidities, health behavior, health competence, and prior hospitalizations (by contribution to indirect effect).

Conclusion: Patient-level factors drive the relationship between low HL and mortality. Health competence and health behavior are modifiable mediators that could be targeted by interventions.

Introduction

After hospitalization for cardiovascular disease (CVD), patients must understand and integrate new information to perform complicated self-care behaviors and manage new medications, lifestyle changes, and follow-up appointments.[1] Success is influenced by their ability to read and understand text-based resources; locate and interpret reliable health information; use numbers for tasks such as adherence to medications; and listen effectively to instructions.[2] Collectively, these abilities are conceptualized as health literacy (HL)[3, 4] which is a multidimensional construct[5] largely formed early in life alongside educational attainment.[4] Previous cohort studies have demonstrated that low HL independently predicts mortality in community-dwelling elders[6, 7] and adults with congestive heart failure (CHF),[8, 9] and after hospitalization for CHF.[10, 11] However, cohort studies have not explored the link between HL and mortality among adults with acute coronary syndromes (ACS).[12]

Despite emphasis on HL as an important determinant of mortality among adults with CVD,[2] the mechanisms by which HL might lead to increased mortality are poorly understood. Research identifying modifiable targets linking low HL to poor outcomes is needed to inform interventions among adults with CVD.[5, 9, 13, 14] Mediation analysis elucidates relationships between a predictor and outcome by examining variables (mediators) posited to lie in the causal pathway. Several hypothesized mediators link low HL to adverse health outcomes, including death.[15] For instance, low HL has been linked to less ability to understand, be motivated towards,[16] and perform successful self-management[3] and having inadequate social support[14] for maintaining health care follow-ups and self-management. Furthermore, low HL may affect post-discharge outcomes via associations with higher disease prevalence,[10, 17, 18] increased comorbidities,[8] and worse overall health[3, 17] which in turn may lead to increased mortality.[8]

Few studies[19–27] have explored mediators of the effects of HL on patient outcomes, and to our knowledge, none has explored mediators of the relationship between HL and mortality in any population. Therefore, we tested hypothesized[13, 15] patient-level behavioral, social, and clinical mediators of effects of HL on 1-year mortality among adults hospitalized for CVD.

Methods

The Vanderbilt Inpatient Cohort Study (VICS) was a 5-year prospective study which enrolled 3,000 adult patients treated at Vanderbilt University Hospital October 11, 2011 through December 18, 2015. VICS was designed to examine how social determinants, in particular HL, affect care transitions and outcomes. Participants had a physician-confirmed diagnosis of ACS and/or acute decompensated heart failure (ADHF) for the index hospitalization. Patients were excluded if they had dementia or unstable psychiatric illness, were unable to communicate in English, or were in hospice care or too ill to complete an interview. The Vanderbilt University Institutional Review Board approved all study procedures. Mediators and covariates were specified *a priori*[13] drawing on a conceptual causal model of the pathways by which HL may affect health outcomes.[15] We focused on the patient-level mediators, excluding provider and health care system factors in the proposed model.[15] Details of the study design have been published.[13]

Measures

Informed consent and interviews were completed at the patients' bedside by a trained research assistant, generally within 24 hours of hospitalization. CVD diagnosis and comorbidities were determined from electronic health record data and mortality data were gathered from multiple sources.

Predictor: Health Literacy (HL).—We assessed Hl with the Brief Health Literacy Screen (BHLS),[28, 29] the short form of the Test of Functional Health Literacy in Adults (S-TOFHLA),[30, 31] a 3-item version of the Subjective Numeracy Scale (SNS-3),[32–34] and years of education (self-report). The BHLS is a subjective measure, asking patients to report their level of confidence filling out medical forms, need for assistance in reading hospital materials, and understanding of written medical information. The S-TOFHLA is an objective test in which respondents choose words missing from text representing medical directions and information about health care. The SNS-3 asks patients to rate their own math skills and preferences for numerical information.

Covariates.—Potential confounders included as covariates were age, male gender, minority race/ethnicity, and socioeconomic status (SES). Race and ethnicity responses were combined to characterize participants as non-Hispanic White or minority. Participant-reported indicators of SES included employment status (3-level categorical variable: employed full- or part-time, disabled or, referent, able to work but not working), financial strain, household income, and insurance status (dichotomized: underinsured, including uninsured or public insurance only, versus adequately insured). Financial strain was assessed using a single question, "How difficult is it for you (and your family) to pay your monthly bills?,"[35] analyzed as a continuous variable with higher scores reflecting greater difficulty. Household income was assessed with modified strata from the Behavioral Risk Factor Surveillance System questionnaire.[36]

Mediators.—Social/behavioral mediators included health competence, health behaviors, and social support. Clinical mediators included a comorbidity index, CVD diagnosis, and prior year hospitalizations.

Health competence was assessed with two items from the Perceived Health Competence Scale:[37] "It is difficult for me to find effective solutions for health problems that come my way" (reverse scored) and "I am able to do things for my health as well as most other people." Higher scores indicate a higher belief in one's capacity to optimize his/her health outcomes.

Health behavior was assessed with a Health Behavior Index[38] which reflects 6 health behaviors assessed with validated scales or items: medication adherence, resilient coping, smoking, alcohol consumption, diet, and exercise. The domain scores are summed to produce an index score, with higher scores indicating healthier behaviors.

Social support was assessed with the Enhancing Recovery in Coronary Heart Disease (ENRICHD) Social Support Inventory,[39, 40] which includes 6 questions regarding emotional and instrumental support, and a categorical variable called home status (3-level variable: married/partnered, living alone and not married/partnered or, referent, not married/partnered but living with someone).

Comorbidities.: We used an index by van Walraven that provides a weighted summary score for the presence or absence of 30 conditions identified by Elixhauser.[41] We did not include the weight for CHF in the index score because this diagnosis was a separate variable in the analyses.

CVD diagnosis was a 3-level categorical variable: ACS only (referent), ACS with CHF history, and ADHF at index hospitalization.

Prior year hospitalizations.: Participants reported how many hospitalizations they had experienced in the 12 months prior to the index hospitalization.

Outcome: 1-year mortality.—Mortality data were gathered using a combination of data from the Social Security Administration's Death Master File (DMF),[42] documentation in the electronic health record, family report, and obituaries. During this study, the DMF was downloaded monthly into the Vanderbilt Enterprise Data Warehouse and linked to patient records by social security number or, when that was not available, through a matching algorithm that utilizes other variables. The DMF is widely used in research[43, 44] and provides accurate matches for death (> 90% among American-born individuals), but does omit some events. Supplementing and verifying DMF data with other sources provides a highly accurate ascertainment of vital status. We have complete follow-up on all participants for at least 1 year; for this analysis, we constructed a dichotomous variable reflecting all-cause death within 365 days of hospital discharge.

Note: Although HL measures were captured at the time of enrollment, we assume that HL remains reasonably constant over time and therefore precedes and is a potential cause of all

mediating variables. Although the constancy of HL over the lifespan is debated,[4, 45] there is little support that the proposed mediating variables cause or quickly change HL.

Analyses

Analyses were performed using Stata 14.2 or AMOS 24.0 with $P<.05$ considered statistically significant.

Latent variable analysis.—Often constructs of interest are not directly observable but rather merely estimated by observed indicators (measures), each of which have varying strengths, limitations, degree of error and/or measure different aspects of a multidimensional construct. Latent variable analysis obtains a robust representation of constructs by combining indicators using the variance/covariance matrix.[46] HL, SES, and social support, are each multidimensional constructs. Therefore, we conducted latent variable analysis with multiple indicators for each construct using structural equation modeling (SEM) prior to mediation analysis. We developed latent variables for HL (indicator variables: S-TOFHLA, BHLS, SNS-3, education), SES (indicator variables: employed, disabled, financial strain, income, underinsured), and social support (indicator variables: ENRICHD and home status indicators married and living alone) following guidelines for measurement model development in SEM.[46] Model fit was assessed using thresholds for multiple fit indices (the comparative fit index, CFI≥0.95; the root mean square error of approximation, RMSEA≤0.06 with confidence interval [CI] 0.00–0.08; and the standardized root mean square residual, SRMR<0.08).[46] Good model fit indicates the variance/covariance matrix implied by the model does not differ significantly from that observed in the data.

Mediation analysis.—We used multiple imputation ($m=10$)[47] to impute 1.05% missing data and latent variables. In mediation analysis (Figure 1), the total effect (also known as the *c* path; Figure 1A) is that of the predictor on the outcome in a model without mediators. The addition of mediators to the model (Figure 1B), decomposes the total effect into a direct effect (*c'* path) and a total indirect effect (*ab* path). The direct effect represents the total effect further adjusted for the mediators. The total indirect effect represents the effect of the predictor on the outcome through its effects on the mediators. In this multiple mediator model, we further examine indirect effects for each mediator, adjusted for all other mediators in the model (depicted by curved arrows among mediators in Figure 1B). Indirect effects with bootstrapped 95% confidence intervals (CIs) that exclude zero are consistent with mediation.[48]

To aid in interpretation of significant indirect effects (*ab* paths) in the multiple mediator models, we first regressed each mediator on HL adjusting for covariates and other mediators using linear and multinomial logistic regression models to capture the association of HL and each of the mediators (*a* paths). Next, using logistic regression, we regressed 1-year mortality (yes/no) on the mediators adjusting for HL and confounders to capture the independent effect of each mediator on 1-year mortality (*b* paths). We then used the Karlson, Holm, and Breen (KHB)[49, 50] method (Stata package *khb*[51]) to examine indirect effects in a multiple mediator model.[49, 50] The KHB method addresses key challenges associated with the present analyses: (a) it generates interpretable and meaningful coefficients using average

partial effects (APEs) which provide the absolute difference, on average, in the probability of 1-year mortality for a standard deviation (SD) decrease in health literacy, and (b) it disentangles the contributions of multiple mediators into multiple indirect effects.[52] To capture uncertainty in all effect estimates we used a non-parametric bootstrap with 5,000 replicates.[48, 53] We also conducted a sensitivity analysis for the multiple mediator model with SEM using full information maximum likelihood to handle missing data and bootstrapping to ascertain if the same mediation effects were significant as those identified in the planned analysis. Findings were consistent with those presented here and are not shown.

Results

A total of 44,600 patient charts were screened, identifying 12,736 with a confirmed diagnosis of ACS and/or ADHF. Of these, nearly 30% (3,763) met all eligibility criteria. Eighty percent (3,000) of eligible patients enrolled. Twenty-three participants died during the index hospitalization and were excluded, resulting in a total sample of 2,977 participants. Table 1 shows participant characteristics, describing those who died within 1 year versus those who did not. Per the S-TOFHLA, 17% had inadequate HL; per the BHLS, 23% had low HL. Ten percent (n=304) of the sample died within a year of hospital discharge.

The final measurement model (Figure 2) had good fit (CFI=0.95; RMSEA=0.05, CI [0.05–0.06], SRMR=0.04). Adjusted HL to mediator (*a*) and mediator to 1-year mortality (*b*) paths (Table 2) inform interpretation of indirect effects identified in the multiple mediator model. Lower HL was independently associated with lower health competence, worse health behaviors, lower social support, more prior year hospitalizations, and greater likelihood of being admitted for ADHF. HL was not independently associated with comorbidities. Health competence, health behavior, comorbidities, prior year hospitalizations and CVD diagnosis (either ACS with CHF history or ADHF at index hospitalization) each independently predicted mortality in expected directions, but social support did not.

Table 3 shows results from the multiple mediator model (Figure 1B) including: AORs and 95% CIs for the total, direct, and indirect effects and covariates. For the indirect effects, AORs inform which effects are significantly different from zero but are not substantively meaningful; APEs are presented for substantive interpretation. Lower HL was associated with a higher probability of 1-year mortality in the base model (total effect AOR=1.31, CI [1.01, 1.69]). When mediators were included, there was no direct effect of HL on 1-year mortality (AOR=0.87, CI [0.66, 1.14]). Therefore the relationship between HL and 1-year mortality was driven by the mediators (total indirect effect AOR=1.50, CI [1.35, 1.67]); each SD decrease in HL was associated with a 3.2 percentage point increase (absolute difference) in the probability of death within 1 year through its association with the mediators. The mediators contributing most to the indirect effect were ADHF at index hospitalization (contributing an absolute 1.69 percentage points) and comorbidities (absolute 0.54 percentage points), but health behavior (0.44), health competence (0.42), and prior year hospitalizations (0.38) each contributed as well. Neither social support nor a history of CHF among those hospitalized for ACS mediated the effect of HL on mortality. Older age and lower SES independently predicted 1-year mortality.

Discussion

We examined hypothesized mediators of the effects of HL on 1-year mortality among adults hospitalized with CVD and extended research on the HL-mortality relationship among patients with CHF to include those with ACS. The mechanisms by which lower HL placed patients with CVD at greater risk for post-discharge mortality included greater likelihood of a CHF exacerbation, more comorbidities, more previous hospitalizations, lower perceived health competence, and worse health behaviors. The effect of HL via these mediators (the indirect effect) was sizable – each SD reduction in HL was associated with an average absolute increase of 3.2 percentage points in 1-year mortality. At extremes (±2 SDs from the mean), a patient with very low HL would be, on average, 12.8% more likely to die within 1 year of hospitalization for CVD than a patient with very high HL, after adjustment for age, gender, minority status, and SES. Although we expected social support to mitigate some of the risk associated with low HL, social support, as operationalized in this analysis, did not mediate the effect of HL on 1-year mortality. After adjustment for mediators, *HL no longer predicted mortality* (nonsignificant direct effect), but older age and lower SES remained significant predictors of 1-year mortality post-discharge.

In this study, the magnitude of the relationship between HL and mortality was similar to other published reports among community-dwelling adults (adjusted hazard ratios 1.52[6], 1.75[7]) and among adults with CHF (adjusted hazard ratios 1.34[10], 1.94[8], 1.91[9, 11]). The relationship between lower HL and mortality in our sample of inpatients with CVD (where 39.2% had ACS only) was consistent with McNaughton et al.'s[10] finding among inpatients with CHF (1.31 total and 1.50 indirect effects as compared to 1.34, respectively). Our examination is the most robust exploration of the HL and mortality relationship in terms of our measurement of HL and the social, behavioral and clinical determinants included. Our use of a latent variable to operationalize HL aligns with conceptual definitions[3, 4] by including reading comprehension, self-rated ability to perform health care tasks, numeracy, and education. Other studies have used single measures assessing only reading ability[6, 7, 11] or subjective self-report.[8–10] Because measures of HL agree less than half the time in identifying those with low HL,[54] use of single measures can substantively impact findings.

Strengths & Limitations

This study is the first to examine mediators of the relationship between HL and mortality to elucidate causal pathways and guide interventions. Strengths include use of a latent variable approach that overcomes bias and shortcomings associated with individual measures for a more robust estimation of important constructs such as HL, social support and SES. We also collected mortality data comprehensively by confirming all deaths using multiple sources. We used a previously hypothesized causal model[13] to select mediators and covariates, although we acknowledge that different relationships could be posited. For instance, HL likely influences and *is influenced by* access to care (e.g., insurance status), health care utilization, and SES. Other limitations include the possibility of unmeasured confounders, use of self-report for health behaviors, single time-point assessments for social and behavioral mediators, and not examining causal paths between the mediators (e.g., social support could lead to improved health behavior which, in turn, could lead to lower mortality

risk). Furthermore, we excluded patient-provider level variables that could mitigate effects of low HL on mortality, such as trust and communication quality. This study was performed at a single referral hospital in the southeast United States; however, participants resided in 20 states. Results should be replicated in samples with more racial/ethnic minorities.

Clinical Implications

Among adults with CVD, increasing perceived health competence and improving health behaviors may mitigate some of the risk associated with low HL, independent of clinical risk factors (i.e. comorbidities, CVD diagnosis, prior hospitalizations). Interventions such as health coaching[55] and cardiac rehabilitation[56] improve perceived health competence and health behaviors and may be particularly effective at reducing risk for post-discharge mortality when effectively delivered to patients with lower HL. These findings suggest patients screened to have low HL while hospitalized with CVD should further be assessed for perceived health competence and health behaviors to inform delivery of appropriate targeted interventions (e.g., health coaching for smoking cessation and dietary modifications; cardiac rehabilitation for individualized exercise programs; counseling for treatment of alcohol abuse) based on the patients' specific health behaviors and requisites for management of their cardiovascular condition. Identification of adults with limited HL or low perceived health competence can be a first step to providing tailored interventions targeting these modifiable constructs to prevent poor outcomes, though future research studies with such interventions would be needed for confirmation. Additionally, low HL may exert its strongest effects on mortality risk via the development of worsening health over the life course, suggesting identification of limited HL early in life is critical, and future research should explore the causal mechanisms linking lower HL to development of CVD and other conditions.

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Abbreviations:

ACS	acute coronary syndromes
ADHF	acute decompensated heart failure

APE	average partial effects
BHLS	Brief Health Literacy Screen
CHF	congestive heart failure
CVD	cardiovascular disease
DMF	Death Master File
ENRICHD	Enhancing Recovery in Coronary Heart Disease Social Support Inventory
KHB	Karlson, Holm, and Breen method
HL	health literacy
SD	standard deviation
SEM	structural equation modeling
SES	socioeconomic status
SNS-3	Subjective Numeracy Scale 3-item version
S-TOFHLA	short form of the Test of Functional Health Literacy in Adults
VICS	Vanderbilt Inpatient Cohort Study

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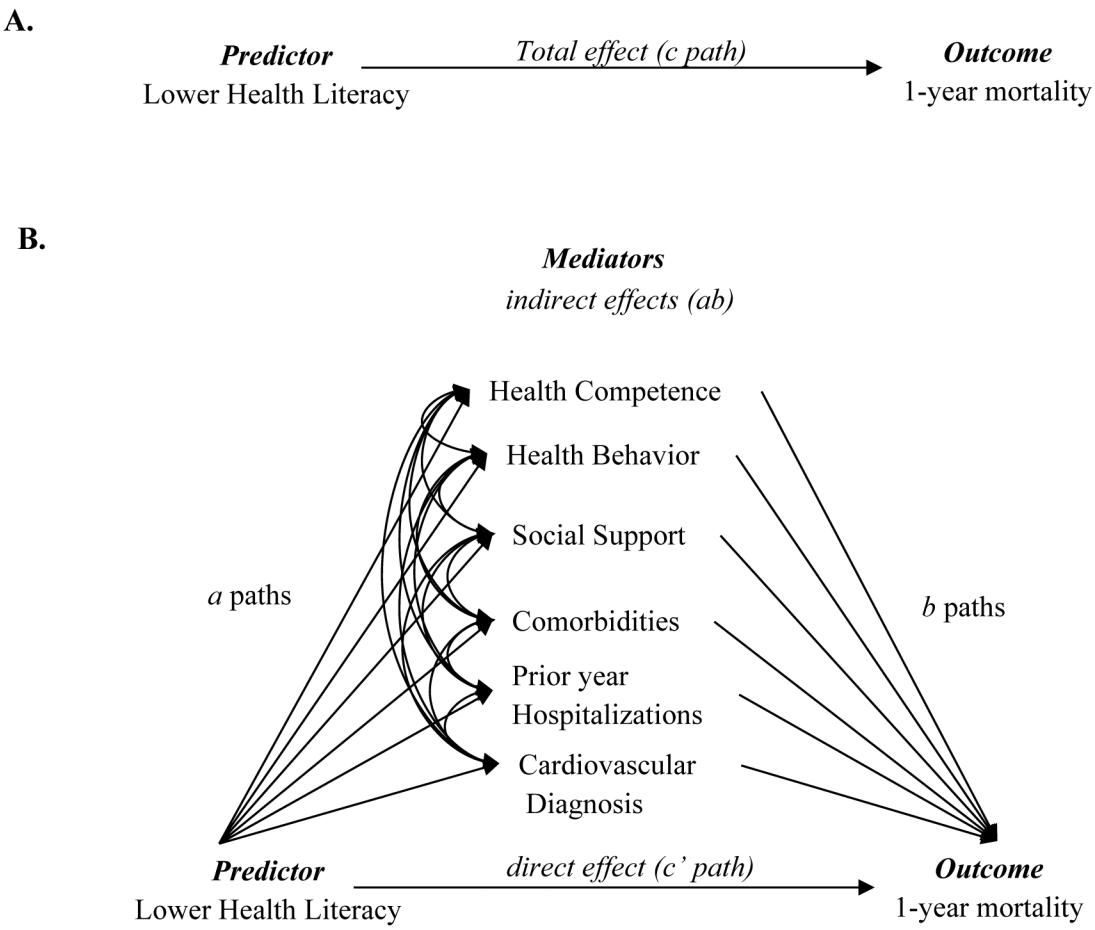

Figure 1. Mediation models examining the relationship between lower health literacy (HL) and 1-year mortality.

A) Base model (no mediators); total effect (*c*) of lower HL on 1-year mortality adjusted for covariates. B) Multiple mediator model; decomposes total effect into a direct (*c'*) and total indirect (*ab*) effect. Direct effect (c') depicts effect of lower HL on 1-year mortality adjusted for all covariates and mediators; *a* paths depict effects of lower HL on each mediator adjusted for other mediators and covariates; *b* paths depict effects of mediators on 1-year mortality adjusted for all other mediators, covariates, and HL. The Karlson, Holm, & Breen method used for analyses adjusts for other mediators when calculated separate effects of each (depicted with curved arrows). Covariates were age, gender, minority status, and socioeconomic status (not shown).

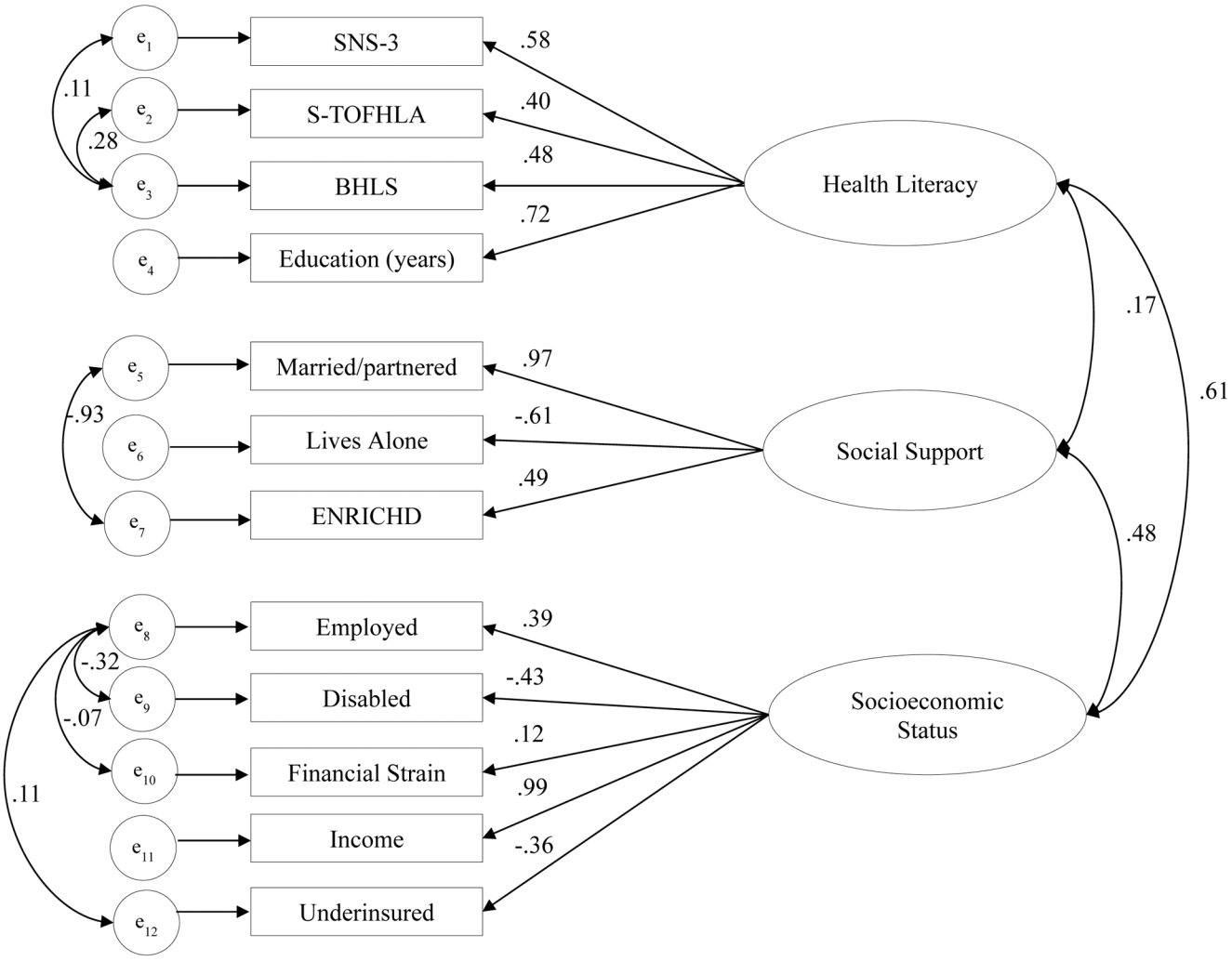

Figure 2. Final measurement model used for latent variables used in mediation analyses.

The three latent variables used in mediation analyses were Health Literacy, Social Support, and Socioeconomic Status. The numbers (right to left) depict: correlations between the latent variables; standardized coefficients for the factor loading of each indicator (measure); correlations between the residual measurement error (e) for some indicators. BHLS = Brief Health Literacy Screen; ENRICHD = Enhancing Recovery in Coronary Heart Disease Social Support Inventory; SNS-3 = Subjective Numeracy Scale-3; S-TOFHLA = Short form of the Test of Functional Health Literacy in Adults.

Table 1.

Participant characteristics stratified by 1-year mortality and total.

	Survived (n=2673)	Died (n=304)	Total (N=2,977)	
COVARIATES	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %	Range [IQR]
Age, years	60.1 (12.3)	63.8 (13.4)	60.5 (12.5)	20 – 95 [53, 69]
Race/Ethnicity				
Non-Hispanic White	83.2 %	82.5 %	83.1 %	
Non-Hispanic Black	12.9 %	13.8 %	13.0 %	
Hispanic	2.2 %	1.0 %	2.0 %	
Other race/ethnicity	1.7 %	2.6 %	1.8 %	
Male	59.9 %	56.6 %	59.6 %	
Socioeconomic Status				
Employment Status				
Employed	37.1 %	8.3 %	41.1 %	
Disabled, unable to work	23.1 %	39.1 %	34.1 %	
Able to work but not working	39.8 %	52.6 %	24.8 %	
Financial Strain				
Somewhat/very difficult to pay bills	44.9 %	51.8 %	45.6 %	
Income (USD)				
<$20,000	20.8 %	30.8 %	21.8 %	
$20,000 – $34,999	24.9 %	28.7 %	25.3 %	
$35,000 – $49,999	16.0 %	20.1 %	16.5 %	
$50,000 – $74,999	14.5 %	11.1 %	14.1 %	
≥$75,000	23.8 %	9.3 %	22.3 %	
Insurance Status				
Uninsured	7.2 %	2.3 %	6.7 %	
Public (Medicare, Medicaid) only	53.6 %	80.6 %	56.3 %	
Private (Commercial, Other)	39.2 %	17.1 %	37.0 %	
PREDICTOR				
Health Literacy				
Education, years	13.7 (2.9)	13.3 (3.1)	13.6 (2.9)	1 – 25 [12, 16]

	Survived (n=2673)	Died (n=304)	Total (N=2,977)	
S-TOFHLA	29.7 (7.5)	25.6 (9.5)	29.4 (7.8)	0 – 36 [26, 35]
BHLS	11.8 (3.1)	11.2 (3.3)	11.8 (3.1)	2 – 15 [10, 15]
SNS-3	4.5 (1.3)	4.2 (1.4)	4.4 (1.3)	1 – 6 [3.7, 5.7]
MEDIATORS				
Health Competence (PHCS-2)	7.8 (2.2)	6.8 (2.2)	7.7 (2.2)	2 – 10 [6, 10]
Health Behavior (HBI)	6.9 (1.4)	6.5 (1.2)	6.8 (1.4)	2.0 – 10.6 [5.9, 7.8]
Social Support				
Home Status				
Married/partnered	61.0 %	52.2 %	60.1 %	
Lives alone	19.2 %	24.7 %	20.2 %	
Lives with someone (not spouse/partner)	19.8 %	23.1 %	19.7 %	
ENRICHD Social Support Inventory	25.9 (4.6)	25.8 (4.8)	25.9 (4.6)	6 – 30 [24, 30]
Comorbidities (adjusted Elixhauser score)	9.4 (9.0)	17.2 (9.5)	10.2 (9.3)	−11 – 60 [3, 16]
Prior Year Hospitalizations	1.3 (2.0)	2.5 (2.7)	1.4 (2.1)	0 – 24 [0, 2]
Cardiovascular Disease Diagnosis				
ACS only	43.0 %	6.6 %	39.2 %	
ACS with CHF history	24.3 %	18.4 %	23.7 %	
ADHF at index hospitalization	32.7 %	75.0 %	37.1 %	

Latent constructs bolded: Socioeconomic Status, Health Literacy, or Social Support, with indicator variables italicized. M (SD) = mean (standard deviation); IQR, interquartile range. ACS, acute coronary syndromes; ADHF, acute decompensated heart failure; BHLS, Brief Health Literacy Screen; CHF, congestive heart failure; ENRICHD, Enhancing Recovery in Coronary Heart Disease; HBI, health behavior index; PHCS-2, Perceived Health Competence Scale-2 item version; S-TOFHLA, Short Test of Functional Health Literacy in Adults; SNS-3, Subjective Numeracy Scale, 3 item.

Table 2.

Adjusted regression models examining *lower* Health Literacy to Mediator (a paths) and Mediator to 1-year Mortality (b paths).

a paths: Lower Health Literacy → Mediator	**Unstandardized**				**Standardized**
	b	95% Confidence Interval		*P* value	β
Health Competence	−0.718	−0.833	−0.602	<.001	−0.437
Health Behavior	−0.431	−0.516	−0.347	<.001	−0.418
Social Support	−0.261	−0.377	−0.145	<.001	−0.224
Comorbidities	0.681	−0.226	1.588	.13	0.100
Prior Year Hospitalizations	0.335	0.206	0.465	<.001	0.216
CVD Diagnosis (referent, ACS only)	LOR	95% Confidence Interval		*P* value	RRR
ACS with CHF history	0.047	−0.293	0.198	.70	1.049
ADHF at index hospitalization	0.303	0.051	0.554	.02	0.739

b paths: Mediator → 1-year mortality	**Unstandardized**				**Standardized**
	LOR	95% Confidence Interval		*P* value	AOR for SD increase
Health Competence	−0.064	−0.127	0.001	.05	0.866
Health Behavior	−0.126	−0.240	−0.124	.03	0.837
Social Support	0.008	−0.100	0.116	.89	1.013
Comorbidities	0.041	0.027	0.055	<.001	1.464
Prior Year Hospitalizations	0.102	0.051	0.152	<.001	1.241
CVD Diagnosis (ACS only, referent)	LOR	95% Confidence Interval		*P* value	AOR
ACS with CHF history	1.146	0.612	1.680	<.001	3.146
ADHF at index hospitalization	2.049	1.554	2.543	<.001	7.760

All models adjusted for covariates: age, gender, minority status, and socioeconomic status; *a* paths show effect of lower health literacy on each mediator in separate models adjusted for all other mediators, *b* paths show effect of each mediator on 1-year mortality in single model adjusted for all mediators and health literacy. **β**, standardized regression coefficients, represent the standard deviation change in the outcome associated with each standard deviation decrease in health literacy; LOR, log odds ratio; AOR for SD increase, the adjusted odds ratio (AOR) for a one standard deviation (SD) increase in the predictor.

Table 3.

Multiple mediator model of *lower* health literacy effects on 1-year mortality, with contributions of each mediator to the indirect effect, adjusted for covariates.

	AOR	95% Confidence Interval	APE (%)
Total Effect (*c*)	1.31	1.01, 1.69	2.11
Direct Effect (*c'*)	0.87	0.66, 1.14	−1.10
Indirect Effect (*ab*)	1.50	1.35, 1.67	3.20
Decomposition of Indirect Effect			
via Health Competence	1.07	1.02, 1.13	0.42
via Health Behavior	1.06	1.01, 1.11	0.44
via Social Support	1.00	0.99, 1.01	−0.01
via Comorbidities	1.06	1.04, 1.10	0.54
via Prior Year Hospitalizations	1.05	1.03, 1.08	0.38
via CVD Diagnosis (ACS only, referent)			
ACS with CHF history	0.97	0.95, 1.00	−0.26
ADHF at index hospitalization	1.27	1.18, 1.37	1.69
Covariates			
Age (10 years)	1.30	1.18, 1.42	na
Male	1.13	0.86, 1.48	na
Minority	0.74	0.52, 1.05	na
Socioeconomic Status (SD increase)	0.81	0.68, 0.96	na

Results calculated using Karlson, Holm, and Breen method and 95% confidence intervals bias corrected with 5,000 bootstraps. AOR, adjusted odds ratio; APE, average partial effects interpreted as the absolute percentage point change in the outcome associated with a standard deviation decrease in health literacy; na, not available; SD, standard deviation.