

# Health Literacy and Mortality Among Elderly Persons

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**Background:** Individuals with low levels of health literacy have less health knowledge, worse self-management of chronic disease, lower use of preventive services, and worse health in cross-sectional studies. We sought to determine whether low health literacy levels independently predict overall and cause-specific mortality.

**Methods:** We designed a prospective cohort study of 3260 Medicare managed-care enrollees in 4 US metropolitan areas who were interviewed in 1997 to determine their demographic characteristics, chronic conditions, self-reported physical and mental health, and health behaviors. Participants also completed the shortened version of the Test of Functional Health Literacy in Adults. Main outcome measures included all-cause and cause-specific (cardiovascular, cancer, and other) mortality using data from the National Death Index through 2003.

**Results:** The crude mortality rates for participants with adequate (n=2094), marginal (n=366), and inadequate (n=800) health literacy were 18.9%, 28.7%, and 39.4%,

respectively ( $P < .001$ ). After adjusting for demographics, socioeconomic status, and baseline health, the hazard ratios for all-cause mortality were 1.52 (95% confidence interval, 1.26-1.83) and 1.13 (95% confidence interval, 0.90-1.41) for participants with inadequate and marginal health literacy, respectively, compared with participants with adequate health literacy. In contrast, years of school completed was only weakly associated with mortality in bivariate analyses and was not significant in multivariate models. Participants with inadequate health literacy had higher risk-adjusted rates of cardiovascular death but not of death due to cancer.

**Conclusions:** Inadequate health literacy, as measured by reading fluency, independently predicts all-cause mortality and cardiovascular death among community-dwelling elderly persons. Reading fluency is a more powerful variable than education for examining the association between socioeconomic status and health.

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**E** DUCATION, AS MEASURED BY the number of years of school completed, is an important predictor of mortality.<sup>1,2</sup> Wong and colleagues<sup>3</sup> reported that, in the United States, persons without a high-school education lost 9.2 more potential life-years per person than did individuals who had completed high school or more. Although the association between education and life expectancy is well documented, the underlying causal pathways are poorly understood. Much of the association between education and health is caused by the positive effect of education on job opportunities, annual income, housing, access to nutritious foods, and health insurance.<sup>4-6</sup> Higher levels of education could also have direct effects on health through greater health knowledge acquired during schooling and

greater personal empowerment and self-efficacy.<sup>7-9</sup>

Another possible mechanism by which education could exert a direct effect on health is reading fluency. The number of years of school completed is strongly associated with reading fluency.<sup>10-13</sup> As a result, individuals with more education tend to have a better capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions: ie, they have higher levels of health literacy.<sup>14,15</sup> Inadequate health literacy (eg, the inability to read and comprehend basic health-related materials such as prescription bottles and appointment slips) is associated with less knowledge among patients with chronic diseases, worse self-management skills, and lower use of preventive services.<sup>16,17</sup> According to the 2003 Na-

tional Assessment of Adult Literacy, more than 75 million adults in the United States have only basic or less than basic health literacy.<sup>18</sup> Inadequate health literacy is associated with worse health in cross-sectional studies,<sup>19-21</sup> and direct measures of health literacy are more strongly associated with self-reported health than the number of years of school completed.<sup>21,22</sup>

Few prospective studies have examined the relationship between health literacy and adverse health outcomes. People with inadequate health literacy have 29% to 52% higher hospitalization rates, even after adjustment for baseline socioeconomic status, health status, and health behaviors.<sup>19,23</sup> Sudore and colleagues<sup>24</sup> reported that, among community-dwelling adults aged 70 to 79 years without physical limitations, worse performance on the Rapid Estimate of Adult Literacy in Medicine (REALM), a word-recognition and pronunciation test,<sup>25</sup> was associated with higher mortality. We analyzed differences in mortality during a 6-year period among a cohort of 3260 Medicare managed-care enrollees 65 years and older who had undergone a detailed baseline interview to assess annual income, education, chronic conditions, physical and mental health, health behaviors, and reading comprehension.

## METHODS

The study design for this project was approved by the institutional review board of Northwestern University. The initial recruitment and baseline data collection for this study have been described previously.<sup>23</sup> Briefly, new Medicare enrollees 65 years and older in 4 health care plans (Cleveland, Ohio; Houston, Texas; Tampa, Florida; and Ft Lauderdale/Miami, Florida) of a national managed care organization were sent a letter of introduction. One week later, interviewers called each enrollee to determine eligibility. Individuals were ineligible if they were not comfortable speaking English or Spanish, were blind or had a severe vision problem, or did not know what year or month it was, the state where they lived, the year they were born, or their address.

### BASELINE INTERVIEW AND TESTS OF HEALTH LITERACY

A total of 3344 participants (49.6% of all 6742 eligible) completed a 1-hour face-to-face home interview between July 1 and December 31, 1997. Participants were very similar to nonparticipants.<sup>23</sup> The survey assessed race/ethnicity, education, annual income, health behaviors (ie, smoking, alcohol consumption, and exercise), body mass index (calculated as weight in kilograms divided by height in meters squared), chronic medical conditions (ie, hypertension, diabetes mellitus, heart disease, chronic obstructive pulmonary disease or asthma, arthritis, or cancer), depression (measured by the Geriatric Depression Scale),<sup>26</sup> self-rated physical and mental health (measured by the 12-Item Short-Form Health Survey),<sup>27</sup> impairments in instrumental activities of daily living, and use of health care services and prescription medications.

Health literacy was evaluated by measuring each enrollee's reading fluency using a shortened version of the Test of Functional Health Literacy in Adults (S-TOFHLA) that included 2 reading passages (36 items worth 2 points each) and 4 numeracy items (7 points each) to assess comprehension of hospital forms and labeled prescription vials that contained numerical information<sup>28,29</sup>; this test assesses quantitative skills and

the ability to read and understand prose and documents. The sum of the 2 sections yields the S-TOFHLA score, which ranges from 0 to 100. Scores from 0 to 55 indicate inadequate health literacy; these individuals will often misread the simplest materials, including prescription bottles and appointment slips. Scores from 56 to 66 indicate marginal health literacy, and scores from 67 to 100 indicate adequate health literacy; the latter group will successfully complete most of the reading tasks required to function in the health care setting but may misread the most difficult numerical information. Respondents who could not read at all (n=10) were assigned a score of 0. We excluded participants whose corrected vision was worse than 20/100 based on results of testing with a Rosenbaum Handheld Vision Chart (n=71) and individuals who could not complete the S-TOFHLA for other reasons (n=13), leaving 3260 people for analysis. Cognitive function was measured by the Mini-Mental State Examination.<sup>30</sup>

### IDENTIFICATION OF PARTICIPANT DEATHS

We used the National Death Index to identify deaths through 2003. The National Death Index provided possible matches based on participants' name, Social Security number, and birth information (month, day, and year). A total of 714 death certificates contained information that exactly matched a participant's first and last name, Social Security number, and birth date. An additional 101 matches were identified from death certificates that matched at least 3 of these 4 identifiers, as well as additional identifiers such as race, sex, and marital status. Cause of death was determined from *International Classification of Diseases, Ninth Revision*, codes, and participants were classified as cardiovascular death, cancer death, other death, or alive through 2003.

### STATISTICAL ANALYSIS

All analyses were conducted using Stata statistical software, version 9 (StataCorp, College Station, Texas). The relationship between health literacy and time to death was first examined using Kaplan-Meier curves, and unadjusted hazard ratios (HRs) were determined from Cox proportional hazards models. We then adjusted for differences in demographic characteristics, socioeconomic status, health behaviors, the number of chronic medical conditions, and self-reported physical and mental health in multivariate Cox models. We imputed annual income on the basis of age, sex, race/ethnicity, health literacy, past occupation, and health status for 16.2% of participants who refused to report their income. We assessed interaction terms between literacy and all other significant variables and examined models stratified by race/ethnicity and language, age, and baseline health status to determine whether associations between literacy and mortality varied according to these characteristics.

Differences in the proportion of patients who died of specific causes (ie, cardiovascular, cancer, and other) were determined by  $\chi^2$  tests. To examine differences in cause-specific mortality, we conducted 3 separate multivariate Cox models for cardiovascular death, cancer death, and combined noncardiovascular and noncancer deaths; ie, for each model the dependent variable was time to cause-specific death with censoring of individuals who died of causes other than the outcome variable. A 2-sided *P* value of .05 was used to determine statistical significance.

## RESULTS

Among the 3260 participants, 2094 (64.2%) had adequate health literacy, 366 (11.2%) had marginal health

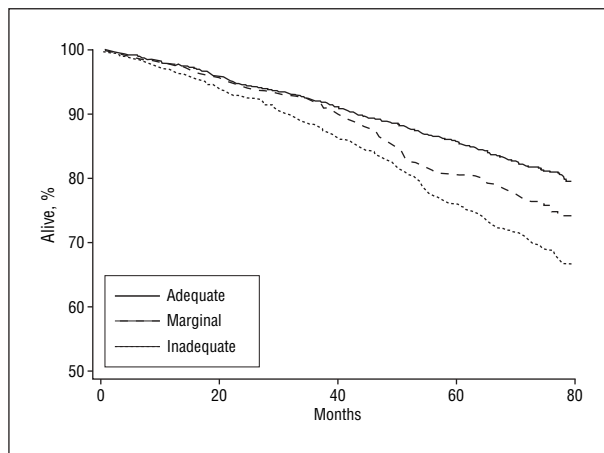
**Table 1. Characteristics of Participants With Adequate, Marginal, and Inadequate Health Literacy<sup>a</sup>**

Characteristic	Health Literacy Groups			P Value
	Adequate (n = 2094)	Marginal (n = 366)	Inadequate (n = 800)	
Age, mean (SD), y	71.6 (5.6)	74.1 (6.3)	75.6 (7.2)	<.001
Female	1213 (57.9)	197 (53.8)	462 (57.8)	.33
Race/ethnicity				<.001
White	1752 (83.7)	249 (68.0)	465 (58.1)	
African American	138 (6.6)	46 (12.6)	200 (25.0)	
Hispanic, English speaking	34 (1.6)	9 (2.5)	18 (2.3)	
Hispanic, Spanish speaking	137 (6.5)	60 (16.4)	103 (12.9)	
Other/missing	33 (1.6)	2 (0.5)	14 (1.8)	
Annual household income				<.001
<\$10 000	252 (12.0)	96 (26.2)	273 (34.1)	
\$10 000-\$14 999	461 (22.0)	97 (26.5)	241 (30.1)	
\$15 000-\$24 999	761 (36.3)	120 (32.8)	216 (27.0)	
\$25 000-\$34 999	303 (14.5)	39 (10.7)	45 (5.6)	
≥\$35 000	317 (15.1)	14 (3.8)	25 (3.1)	
Years of school completed				<.001
Grades 1-8	151 (7.2)	90 (24.6)	328 (41.0)	
Grades 9-11	311 (14.9)	93 (25.4)	194 (24.3)	
High school/GED	801 (38.3)	110 (30.1)	182 (22.8)	
>High school	831 (39.7)	73 (20.0)	96 (12.0)	
No. of chronic conditions, mean (SD)	1.5 (1.2)	1.7 (1.2)	1.7 (1.2)	.87
Physical function score, mean (SD)	46.2 (10.7)	43.6 (11.7)	41.9 (11.9)	<.001
Mental health score, mean (SD)	55.5 (7.9)	54.9 (9.2)	52.1 (10.7)	<.001
IADL limitation	495 (23.6)	137 (37.4)	368 (46.0)	<.001
ADL limitation	62 (3.0)	21 (5.7)	70 (8.8)	<.001
Smoking				<.05
Never	801 (38.3)	156 (42.6)	361 (45.1)	
Former	1030 (49.2)	164 (44.8)	343 (42.9)	
Current	263 (12.6)	46 (12.6)	96 (12.0)	
Current alcohol use <sup>b</sup>				<.001
None	1226 (58.5)	238 (65.0)	601 (75.1)	
Light to moderate	784 (37.4)	121 (33.1)	186 (23.3)	
Heavy	84 (4.0)	7 (1.9)	13 (1.6)	
Vigorous physical activity, times per week				<.001
≥4	988 (47.2)	150 (41.0)	254 (31.8)	
3	314 (15.0)	61 (16.7)	110 (13.8)	
1-2	324 (15.5)	56 (15.3)	113 (14.1)	
<1	468 (22.3)	99 (27.0)	323 (40.4)	
BMI				<.005
<18.5	87 (4.2)	13 (3.6)	62 (7.8)	
18.5-24.9	1211 (57.8)	219 (59.8)	472 (59.0)	
25.0-29.9	543 (25.9)	87 (23.8)	185 (23.1)	
≥30.0	253 (12.1)	47 (12.8)	81 (10.1)	

Abbreviations: ADL, activities of daily living; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); GED, General Education Development; IADL, instrumental ADL.

<sup>a</sup>Unless otherwise indicated, data are expressed as number (percentage) of subjects. Health literacy was assessed by measuring enrollees' reading fluency using a shortened version of the Test of Functional Health Literacy in Adults.

<sup>b</sup>Current alcohol use was classified as *light to moderate* for men who said that they had 1 to 14 drinks of alcohol during the past month and women who said that they had 1 to 7 drinks of alcohol during the past month. Those who drank more than this were classified as *heavy* drinkers.



**Figure.** Age-adjusted survival from the time of study enrollment for participants with adequate, marginal, and inadequate health literacy. Health literacy was assessed by measuring enrollees' reading fluency using a shortened version of the Test of Functional Health Literacy in Adults.  $P < .001$  for age-adjusted differences in survival by literacy.

literacy, and 800 (24.5%) had inadequate health literacy. Individuals with inadequate health literacy were older and more likely to be nonwhite, had less annual income and education, and had worse physical and mental health than did individuals with adequate health literacy (**Table 1**). Participants with inadequate health literacy were less likely to have ever smoked cigarettes and to have used alcohol during the past month, less likely to perform frequent vigorous physical activity, and more likely to be underweight (body mass index,  $<18.5$ ).

A total of 815 participants (25.0%) died during an average follow-up of 67.8 months. Individuals with inadequate and marginal health literacy were more likely to die during follow-up than were those with adequate health literacy (39.4%, 28.7%, and 18.9%, respectively;  $P < .001$ ). After adjusting for age, the HRs were 1.70 (95% confidence interval [CI], 1.46-1.99) for participants with inadequate health literacy and 1.28 (95% CI, 1.03-1.59) for participants with marginal health literacy compared with participants with adequate health literacy (**Figure**). The results were similar after adjusting for demographics and socioeconomic variables (**Table 2**, model 2). After adding self-reported physical and mental health, instrumental activities of daily living limitations, and chronic conditions (Table 2, model 3), the adjusted HR for death for participants with inadequate health literacy was 1.52 (95% CI, 1.26-1.83) and the HR for participants with marginal health literacy was 1.13 (95% CI, 0.90-1.41), which was no longer statistically significant. Older age, male sex, lower annual income, the number of chronic conditions, and worse self-reported physical health and functioning were also associated with higher mortality (Table 2). The results also did not change when we excluded individuals with Mini-Mental State Examination scores of 18 or less and those with a previous stroke.

We explored several possible explanations for the association between literacy and mortality. We added health behaviors to the model (smoking history, body mass index, alcohol use, and physical activity) to determine the degree to which differences in health behaviors explained the excess mortality among participants with in-

**Table 2. Association Between Health Literacy and All-Cause Mortality in Sequentially Adjusted Multivariate Models**

Variable	HR (95% CI)		
	Model 1 <sup>a</sup>	Model 2 <sup>b</sup>	Model 3 <sup>c</sup>
Health literacy <sup>d</sup>			
Adequate	1 [Reference]	1 [Reference]	1 [Reference]
Marginal	1.31 (1.05-1.64)	1.22 (0.98-1.53)	1.13 (0.90-1.41)
Inadequate	1.85 (1.57-2.19)	1.73 (1.45-2.08)	1.52 (1.26-1.83)
Age, y			
65-69	1 [Reference]	1 [Reference]	1 [Reference]
70-74	1.44 (1.16-1.79)	1.44 (1.16-1.79)	1.45 (1.17-1.80)
75-79	2.41 (1.94-2.98)	2.36 (1.90-2.93)	2.23 (1.80-2.76)
80-84	4.11 (3.29-5.15)	3.92 (3.13-4.92)	3.58 (2.85-4.50)
≥85	4.95 (3.82-6.43)	4.79 (3.68-6.25)	4.06 (3.10-5.32)
Sex			
Male	1 [Reference]	1 [Reference]	1 [Reference]
Female	0.58 (0.51-0.67)	0.52 (0.45-0.61)	0.46 (0.39-0.54)
Race/ethnicity			
White	1 [Reference]	1 [Reference]	1 [Reference]
Hispanic, English speaking	0.71 (0.38-1.33)	0.66 (0.35-1.25)	0.73 (0.38-1.38)
Hispanic, Spanish speaking	0.59 (0.43-0.81)	0.50 (0.36-0.70)	0.61 (0.44-0.86)
African American	0.87 (0.69-1.10)	0.78 (0.61-0.98)	0.78 (0.62-1.00)
School completed, y			
>High school		1 [Reference]	1 [Reference]
High school/GED		0.93 (0.77-1.12)	0.95 (0.78-1.15)
Grades 9-11		0.95 (0.76-1.19)	0.91 (0.73-1.14)
Grades 1-8		0.88 (0.69-1.13)	0.85 (0.66-1.10)
Annual household income			
≥\$35 000		1 [Reference]	1 [Reference]
\$25 000-\$34 999		1.22 (0.88-1.68)	1.20 (0.87-1.67)
\$15 000-\$24 999		1.26 (0.95-1.67)	1.08 (0.81-1.43)
\$10 000-\$14 999		1.57 (1.17-2.12)	1.31 (0.97-1.77)
<\$10 000		1.90 (1.39-2.61)	1.52 (1.10-2.09)
Physical health SF-12 score <sup>e</sup>			0.82 (0.76-0.88)
Mental health SF-12 score <sup>e</sup>			0.97 (0.91-1.05)
IADLs (any impairment)			1.41 (1.18-1.70)
ADLs (any impairment)			1.40 (1.09-1.80)
No. of chronic conditions <sup>f</sup>			1.10 (1.04-1.18)

Abbreviations: ADL, activities of daily living; CI, confidence interval; GED, General Education Development; HR, hazard ratio; IADL, instrumental ADL; SF-12, 12-item Short-Form Health Survey.

<sup>a</sup>Adjusted for demographic characteristics.

<sup>b</sup>Adjusted for demographic characteristics, annual income, and education.

<sup>c</sup>Adjusted for demographic characteristics, annual income, education, and health status.

<sup>d</sup>Health literacy was evaluated by measuring enrollees' reading fluency using a shortened version of the Test of Functional Health Literacy in Adults.

<sup>e</sup>Measured per 10-point change.

<sup>f</sup>Range, 0-7.

adequate health literacy, but the results changed little (adjusted HR for inadequate vs adequate health literacy, 1.48; 95% CI, 1.23-1.79). Adding the number of hospitalizations during the year before study entry and the self-reported number of long-term medications at baseline to the model also did not change our results.

### EDUCATION

In contrast to health literacy, years of school completed was only weakly predictive of mortality. The mortality rates were 29.4, 28.4, 22.6, and 23.1 for participants who had completed less than 9 years of school 9 to 11 years of school, high school or General Education Development, or education beyond high school ( $P=.002$ ), respectively. After adjusting for demographics, annual income, and baseline health status (but not health literacy), years of school completed had no association whatsoever with mortality; the adjusted HRs for participants who

had completed less than 9 years of school, 9 to 11 years of school, or high school or General Education Development were 1.01, 0.99, and 0.99, respectively, compared with those who had attended college.

### VARIATION IN THE ASSOCIATION BETWEEN HEALTH LITERACY AND MORTALITY

In multivariate analyses stratified by race/ethnicity, the HRs for participants with inadequate health literacy compared with participants with adequate health literacy were 1.60 (95% CI, 1.29-1.98;  $P<.001$ ) and 2.03 (95% CI, 1.12-3.70;  $P=.02$ ) for white ( $n=2464$ ) and African American ( $n=384$ ) participants, respectively. However, there was no association between health literacy and mortality among Latino participants ( $n=361$ ; adjusted HR, 1.02; 95% CI, 0.51-2.03). The association between health literacy and mortality was stronger among individuals who were in better baseline physical health (interaction term

between inadequate health literacy and physical health,  $P = .002$ ). The adjusted HR for participants with inadequate health literacy compared with participants with adequate health literacy was 2.10 (95% CI, 1.60-2.75) for individuals whose baseline physical health score was 1 SD above the mean (56.2), 1.69 (95% CI, 1.39-2.05;  $P < .001$ ) for individuals at the mean baseline physical health score (44.9), and 1.36 (95% CI, 1.11-1.66) for individuals whose baseline physical health score was 1 SD below the mean (33.6). The association between health literacy and mortality was similar across all age groups.

### CAUSE-SPECIFIC MORTALITY

A total of 380 (11.7%) participants died of cardiovascular disease. Rates were markedly higher for those with inadequate health literacy (19.3%) and marginal health literacy (16.7%) compared with those with adequate health literacy (7.9%;  $P < .001$ ) (Table 3). After adjusting for demographic characteristics, socioeconomic variables, and baseline health status, participants with inadequate health literacy had a higher adjusted relative risk of cardiovascular death (adjusted HR, 1.52; 95% CI, 1.16-2.00) (Table 3). Participants with marginal health literacy also had higher cardiovascular death rates (adjusted HR, 1.39; 95% CI, 1.02-1.90). Crude cancer mortality rates were higher among those with inadequate health literacy, but rates were similar in multivariate models (Table 3). The mortality rate for all noncardiovascular and noncancer causes was also higher among participants with inadequate health literacy in unadjusted and multivariate analyses (Table 3).

### COMMENT

Inadequate health literacy, as measured by reading fluency using the S-TOFHLA, had a strong, independent association with mortality even after adjusting for an extensive set of covariates, including sociodemographic characteristics, chronic conditions, and detailed measures of baseline physical and mental health. The magnitude of the association between inadequate health literacy and mortality was similar to the association between low annual income and mortality. Analysis of cause-specific mortality showed that most of the excess mortality among those with inadequate health literacy was due to higher adjusted mortality rates from cardiovascular disease; the adjusted rates of death due to cancer were similar.

To our knowledge, only 1 previous study has examined the relationship between literacy and mortality. Sudore and colleagues<sup>24</sup> reported that participants in the Health, Aging, and Body Composition Study who scored at the eighth-grade level or lower on the REALM had an adjusted HR of death of 1.75 compared with those at the ninth-grade level. However, this study was restricted to adults aged 70 to 79 years; it excluded non-English speakers and people who reported any difficulty walking one-quarter of a mile, climbing a flight of stairs, or performing basic activities of daily living; and it adjusted for differences in health with a single item measuring self-

**Table 3. Cause-Specific Mortality Rates and HRs According to Health Literacy**

Cause of Death	Health Literacy <sup>a</sup>		
	Adequate (n = 2094)	Marginal (n = 366)	Inadequate (n = 800)
Cardiovascular death, No. (%)	165 (7.9)	61 (16.7)	154 (19.3)
Adjusted HR (95% CI) <sup>b</sup>	1 [Reference]	1.39 (1.02-1.90)	1.52 (1.16-2.00)
Cancer death, No. (%)	122 (5.8)	17 (4.6)	70 (8.8)
Adjusted HR (95% CI) <sup>b</sup>	1 [Reference]	0.65 (0.38-1.09)	1.18 (0.81-1.72)
Death due to all other causes, No. (%)	108 (5.2)	27 (7.4)	91 (11.4)
Adjusted HR (95% CI) <sup>b</sup>	1 [Reference]	1.18 (0.76-1.85)	1.87 (1.32-2.67)

Abbreviations: CI, confidence interval; HR, hazard ratio.

<sup>a</sup>Health literacy was evaluated by measuring enrollees' reading fluency using a shortened version of the Test of Functional Health Literacy in Adults.

<sup>b</sup>Adjusted for age, sex, race/ethnicity, language, study site, annual income, social class, years of school completed, physical and mental health (12-Item Short-Form Health Survey summary scales), instrumental activities of daily living, activities of daily living, and prevalence of chronic conditions.

reported overall health. The Health, Aging, and Body Composition Study also used the REALM, which is a word recognition test and not a measure of current reading fluency, and 18% of the original study population could not undergo testing. In contrast, our study enrolled all patients 65 years or older regardless of health status, used a measure of current reading fluency, and adjusted for differences in baseline health with a comprehensive set of health status measures. Despite these differences, our adjusted mortality rate for those with inadequate literacy was only slightly lower than that of the Health, Aging, and Body Composition Study, and our results were even more similar if we restricted our analyses to participants who preferred English and reported no limitations walking several blocks.

We found that years of school completed was only weakly associated with mortality. Previous studies have shown that the association between education and mortality is less strong among the elderly population.<sup>1,5,6,31,32</sup> For all age groups, years of school completed is an inaccurate measure of true educational attainment because many individuals progress through the educational system without meeting desired goals, including the ability to read at grade level. Years of school completed is more problematic among older persons because it does not capture lifelong learning or age-related declines in reading fluency.<sup>33</sup> Therefore, reading fluency appears to be a more powerful variable than education for examining the relationship between socioeconomic status and health.<sup>22,23</sup>

There are several possible mechanisms by which the association between literacy and mortality might occur. Inadequate health literacy is associated with less knowledge of chronic disease and worse self-management skills for patients with hypertension, diabetes mellitus, asthma, and heart failure.<sup>16,34,35</sup> Low levels of health literacy are also negatively related to patients' knowledge of human immunodeficiency virus medications and dosing instruc-

tions, adherence to the medication regimen, and human immunodeficiency viral load.<sup>36-39</sup> Use of cancer screening and vaccinations are also lower among people with inadequate health literacy.<sup>17</sup> Thus, the association between health literacy and adverse health outcomes probably occurs as the result of a wide variety of pathways that have a cumulative effect.

It remains possible that we overestimated the association between health literacy and mortality owing to an unmeasured confounding variable. We adjusted for annual income, but this does not fully capture economic status. Participants had generous medication benefits and low co-payments at baseline; however, this may have changed over time, and those with inadequate health literacy may have been more likely to face financial barriers to care. It is also likely that individuals with limited health literacy had fewer assets (ie, net worth), even after adjusting for annual income. Net worth may independently predict health outcomes.<sup>40</sup> Patients with inadequate health literacy may also have underreported the presence of medical conditions. It is not clear whether the accuracy of self-reported chronic conditions varies by education.<sup>6,41,42</sup> To mitigate any effect of underreporting, we adjusted for the number of daily medications that participants reported, and our results did not change.

Another possible confounding variable is cognitive function. Previous studies have shown that performance on the S-TOFHLA is correlated with performance on the Mini-Mental State Examination, even for items that should not depend on literacy or education (eg, delayed recall).<sup>43</sup> Performance on the REALM is also associated with Mini-Mental State Examination scores.<sup>44</sup> The National Adult Reading Test, a word recognition test like the REALM, is highly correlated with performance on intelligence tests given decades earlier.<sup>45</sup> Moreover, performance on cognitive function tests is associated with the ability to understand medication instructions,<sup>46</sup> and individuals who perform better on cognitive tests in childhood have lower mortality.<sup>47,48</sup> Additional studies are needed to examine the independent effects of health literacy and cognitive function.

Our study has several other limitations. The S-TOFHLA is not a comprehensive measure of health literacy; more precise and comprehensive measures may have shown a stronger relationship between health literacy and mortality. Only half of eligible new enrollees participated, and nonparticipants had slightly higher socioeconomic status; the association between health literacy and mortality may have differed among nonparticipants. Our study was limited to people 65 years or older, so we cannot extrapolate our findings to younger individuals.

Recent studies suggest that it may be possible to reduce the higher rate of adverse health outcomes among patients with diabetes mellitus and heart failure and inadequate health literacy.<sup>49,50</sup> Although these studies are important, the interventions targeted only 1 aspect of patients' health and health care needs. Most people will have many acute and chronic medical conditions during their life and face many situations in which they must make health and health care choices and decisions. As a result of these myriad demands placed on patients today, wide-

spread improvements in health and health care communication will likely be necessary to reduce the association between health literacy and mortality. To achieve this goal, we must further elucidate the causal pathways linking health literacy and adverse health outcomes and use this information to design more comprehensive and effective interventions.

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