

# Low Health Literacy and Health Outcomes: An Updated Systematic Review

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**Background:** Approximately 80 million Americans have limited health literacy, which puts them at greater risk for poorer access to care and poorer health outcomes.

**Purpose:** To update a 2004 systematic review and determine whether low health literacy is related to poorer use of health care, outcomes, costs, and disparities in health outcomes among persons of all ages.

**Data Sources:** English-language articles identified through MEDLINE, CINAHL, PsycINFO, ERIC, and Cochrane Library databases and hand-searching (search dates for articles on health literacy, 2003 to 22 February 2011; for articles on numeracy, 1966 to 22 February 2011).

**Study Selection:** Two reviewers independently selected studies that compared outcomes by differences in directly measured health literacy or numeracy levels.

**Data Extraction:** One reviewer abstracted article information into evidence tables; a second reviewer checked information for accuracy. Two reviewers independently rated study quality by using predefined criteria, and the investigative team jointly graded the overall strength of evidence.

**Data Synthesis:** 96 relevant good- or fair-quality studies in 111 articles were identified: 98 articles on health literacy, 22 on nu-

meracy, and 9 on both. Low health literacy was consistently associated with more hospitalizations; greater use of emergency care; lower receipt of mammography screening and influenza vaccine; poorer ability to demonstrate taking medications appropriately; poorer ability to interpret labels and health messages; and, among elderly persons, poorer overall health status and higher mortality rates. Poor health literacy partially explains racial disparities in some outcomes. Reviewers could not reach firm conclusions about the relationship between numeracy and health outcomes because of few studies or inconsistent results among studies.

**Limitations:** Searches were limited to articles published in English. No Medical Subject Heading terms exist for identifying relevant studies. No evidence concerning oral health literacy (speaking and listening skills) and outcomes was found.

**Conclusion:** Low health literacy is associated with poorer health outcomes and poorer use of health care services.

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The term “health literacy” refers to a set of skills that people need to function effectively in the health care environment (1). These skills include the ability to read and understand text and to locate and interpret information in documents (print literacy); use quantitative information for tasks, such as interpreting food labels, measuring blood glucose levels, and adhering to medication regimens (numeracy); and speak and listen effectively (oral literacy) (2, 3).

Approximately 80 million U.S. adults are thought to have limited health literacy, which puts them at risk for poorer health outcomes. Rates of limited health literacy are higher among elderly, minority, and poor persons and those with less than a high school education (4). Numerous policy and advocacy organizations have expressed concern about barriers caused by low health literacy, notably the Institute of Medicine’s report *Health Literacy: A Prescription to End Confusion* in 2004 (5) and the U.S. Department of Health and Human Services’ report *National Action Plan to Improve Health Literacy* in 2010 (6).

To understand the relationship between health literacy level and use of health care services, health outcomes, costs, and disparities in health outcomes, we conducted a systematic evidence review for the Agency for Healthcare Research and Quality (AHRQ) (published in 2004), which

was limited to the relationship between print literacy and health outcomes (7). We found a consistent association between low health literacy (measured by reading skills) and more limited health-related knowledge and comprehension. The relationship between health literacy level and other outcomes was less clear, primarily because of a lack of studies and relatively unsophisticated methods in the available studies.

In this review, we update and expand the earlier review (7). Since 2004, researchers have conducted new and more sophisticated studies. Thus, in synthesizing the literature,

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**Context**

Several studies show that people with low health literacy skills have poorer health-related knowledge and comprehension.

**Contribution**

This updated systematic review of 96 studies found that low health literacy is associated with poorer ability to understand and follow medical advice, poorer health outcomes, and differential use of some health care services.

**Caution**

No studies examined the relationship between oral literacy (speaking and listening skills) and outcomes.

**Implication**

Although it is challenging, we need to find feasible ways to improve patients' health literacy skills and reduce the negative effects of low health literacy on outcomes.

—The Editors

we can now consider the relationship between outcomes and health literacy (print literacy alone or combined with numeracy) and between outcomes and the numeracy component of health literacy alone.

**METHODS**

We developed and followed a protocol that used standard AHRQ Evidence-based Practice Center methods. The full report describes study methods in detail and presents evidence tables for each included study (1).

**Literature Search**

We searched MEDLINE, CINAHL, the Cochrane Library, PsycINFO, and ERIC databases. For health literacy, our search dates were from 2003 to May 2010. For numeracy, they were from 1966 to May 2010; we began at an earlier date because numeracy was not addressed in our 2004 review. For this review, we updated our searches beyond what was included in the full report from May 2010 through 22 February 2011 to be current with the most recent literature. No Medical Subject Heading terms specifically identify health literacy-related articles, so we conducted keyword searches, including *health literacy*, *literacy*, *numeracy*, and terms or phrases used to identify related measurement instruments. We also hand-searched reference lists of pertinent review articles and editorials. **Appendix Table 1** (available at [www.annals.org](http://www.annals.org)) shows the full search strategy.

**Study Selection**

We included English-language studies on persons of all ages whose health literacy or that of their caregivers (including numeracy or oral health literacy) had been measured directly and had not been self-reported. Studies had to compare participants in relation to an outcome, includ-

ing health care access and service use, health outcomes, and costs of care. For numeracy studies, outcomes also included knowledge, because our earlier review had established the relationship between only health literacy and knowledge. We did not examine outcomes concerning attitudes, social norms, or patient-provider relationships.

**Data Abstraction and Quality Assessment**

After determining article inclusion, 1 reviewer entered study data into evidence tables; a second, senior reviewer checked the information for accuracy and completeness. Two reviewers independently rated the quality of studies as good, fair, or poor by using criteria designed to detect potential risk of bias in an observational study (including selection bias, measurement bias, and control for potential confounding) and precision of measurement.

**Data Synthesis and Strength of Evidence**

We assessed the overall strength of the evidence for each outcome separately for studies measuring health literacy and those measuring numeracy on the basis of information only from good- and fair-quality studies. Using AHRQ guidance (8), we graded the strength of evidence as high, moderate, low, or insufficient on the basis of the potential risk of bias of included studies, consistency of effect across studies, directness of the evidence, and precision of the estimate (**Table 1**). We determined the grade on the basis of the literature from the update searches. We then considered whether the findings from the 2004 review would alter our conclusions. We graded the body of evidence for an outcome as low if the evidence was limited to 1 study that controlled for potential confounding variables or to several small studies in which all, or only some, controlled for potential confounding variables or as insufficient if findings across studies were inconsistent or were limited to 1 unadjusted study. Because of heterogeneity across studies in their approaches to measuring health literacy, numeracy, and outcomes, we summarized the evidence

**Table 1. Strength of Evidence Grades and Definitions**

Grade	Definition
High	High confidence that the evidence reflects the true effect. Further research is very unlikely to change our confidence in the estimate of effect.
Moderate	Moderate confidence that the evidence reflects the true effect. Further research may change our confidence in the estimate of effect and may change the estimate.
Low	Low confidence that the evidence reflects the true effect. Further research is likely to change our confidence in the estimate of effect and is likely to change the estimate. The evidence was graded as low if findings were limited to only 1 or a few studies that controlled for potential confounding or the preponderance of evidence was based on studies that did not control for potential confounding.
Insufficient	Evidence either is unavailable or does not permit estimation of an effect. Inconsistent findings across studies were generally graded as insufficient, as was evidence limited to 1 study that did not control for potential confounding.

through consensus discussions and did not conduct any meta-analyses.

### Role of the Funding Source

AHRQ reviewed a draft report and provided copyright release for this manuscript. The funding source did not participate in conducting literature searches, determining study eligibility, evaluating individual studies, grading evidence, or interpreting results.

## RESULTS

First, we present the results from our literature search and a summary of characteristics across studies, followed by findings specific to health literacy then numeracy. We generally highlight evidence of moderate or high strength and mention only outcomes with low or insufficient evidence. Where relevant, we comment on the evidence provided through the 2004 review. **Tables 2** and **3** summarize our findings and strength-of-evidence grade for each included health literacy and numeracy outcome, respectively.

### Characteristics of Reviewed Studies

We identified 3823 citations and evaluated 1012 full-text articles (**Appendix Figure**, available at [www.annals.org](http://www.annals.org)). Ultimately, we included 96 studies rated as good or fair quality. These studies were reported in 111 articles because some investigators reported study results in multiple publications (98 articles on health literacy, 22 on numeracy, and 9 on both). We found no studies that examined outcomes by the oral (verbal) component of health literacy. Of the 111 articles, 100 were rated as fair quality. All studies were observational, primarily cross-sectional designs (91 of 111 articles). The **Supplement** (health literacy) and **Appendix Table 2** (numeracy) (both available at [www.annals.org](http://www.annals.org)) present summary information for each included article.

Studies varied in their measurement of health literacy and numeracy. Commonly used instruments to measure health literacy are the Rapid Estimate of Adult Literacy in Medicine (REALM) (9), the Test of Functional Health Literacy in Adults (TOFHLA) (10), and short TOFHLA (S-TOFHLA). Instruments frequently used to measure numeracy are the Schwartz–Woloshin Numeracy Test (11) and the Wide Range Achievement Test (WRAT) math subtest (12).

Studies also differed in how investigators distinguished between levels or thresholds of health literacy—either as a continuous measure or as categorical groups. Some studies identified 3 groups, often called *inadequate*, *marginal*, and *adequate*, whereas others combined 2 of the 3 groups. Because evidence was sparse for evaluating differences between marginal and adequate health literacy, our results focus on the differences between the lowest and highest groups.

Studies in this update generally included multivariate analyses rather than simpler unadjusted analyses. They varied considerably, however, in regard to which potential con-

founding variables are controlled (**Supplement and Appendix Table 2**). All results reported here are from adjusted analyses that controlled for potential confounding variables, unless otherwise noted.

### Relationship Between Health Literacy and Outcomes Use of Health Care Services and Access to Care

*Emergency Care and Hospitalizations.* Nine studies examining the risk for emergency care use (13–21) and 6 examining the risk for hospitalizations (14–19) provided moderate evidence showing increased use of both services among people with lower health literacy, including elderly persons, clinic and inner-city hospital patients, patients with asthma, and patients with congestive heart failure. Outcomes did not differ among adolescents with HIV or among children (based on parents' health literacy) (19, 21). Studies in our 2004 review also found increased hospitalizations (7).

*Preventive Services.* Four studies provided moderate evidence of a lower probability of mammography screening (18, 22–24) and influenza immunizations (22, 23, 25, 26) in low health literacy groups. Two of the mammography studies were conducted in a nationally representative sample of elderly persons. Our 2004 report found similar results (7).

### Health Care–Related Skills

*Taking Medications Appropriately.* Six studies provided moderate evidence that low health literacy is related to poorer skills in taking medications. Three studies directly observed whether participants take prescription medications appropriately and generally found poorer skills among those with low health literacy (27–29). In 1 good-quality study, patients with coronary heart disease and low health literacy were less likely to identify all of their medications (27). Patients with HIV and low health literacy scored significantly lower during a mock exercise that measured management of medication (28). Elderly persons with low health literacy were less able to open and take their medications (29).

Three analyses examined other measures of taking medications properly—self-reported use of nonstandardized dosing instruments (such as kitchen spoons), observation of use of common dosing instruments, and biological test results (30–32). The 2 dosing-instrument studies reported poorer performance among persons with low health literacy (31, 32).

*Interpreting Labels and Health Messages.* Studies provided moderate evidence that low health literacy is associated with poorer interpretation of labels (prescription medications and nutrition) and health messages. Adult patients with low health literacy in primary care clinics were less able to describe how they would take 5 medications and had a greater probability of misunderstanding instructions on 1 or more labels (33). In an unadjusted analysis, they were also less able to correctly interpret 4 of 5 primary medication labels and were

**Table 2. Health Literacy Outcome Results: Strength of Evidence and Summary of Findings, 2004 and 2011**

Outcome	Study Design	Articles (Articles Controlling for Confounding), n (n)		Low vs. Adequate Health Literacy		Strength of Evidence: 2011
		2004	2011	2004	2011	
Access to care	Cohort	0	4 (4)	No difference	Inconsistent	Insufficient
	Cross-sectional	1 (1)	6 (5)			
Access to insurance	Cross-sectional	0	1 (1)	NA: no studies	Decrease	Low
Adherence	Cohort	2 (0)	7 (7)	Inconsistent	Inconsistent	Insufficient
	Cross-sectional	2 (1)	10 (10)			
Alcohol and drug use	Cross-sectional	1 (1)	2 (2)	No difference	Inconsistent	Insufficient
Asthma self-care	Cross-sectional	1 (1)	1 (1)	Decrease	Decrease	Low
Asthma severity and control	Cross-sectional	0	2 (1)	NA: no studies	Inconsistent	Insufficient
Chronic disease	Cohort	1 (1)	2 (0)	No difference	Inconsistent	Insufficient
	Cross-sectional		5 (3)			
Colon cancer screening	Cross-sectional	0	5 (5)	NA: no studies	Decrease	Insufficient
Dental disease	Cross-sectional	0	2 (2)	NA: no studies	Inconsistent	Insufficient
Diabetes control and related symptoms	Cross-sectional	3 (2)	8 (7)	Inconsistent	Inconsistent	Insufficient
Diabetes self-management	Cross-sectional	0	1 (1)	NA: no studies	Decrease	Low
Emergency care visits	Cohort	0	6 (4)	NA: no studies	Increase	Moderate
	Cross-sectional	0	3 (3)			
Seeking health-related information	Cross-sectional	0	1 (1)	NA: no studies	No difference	Low
Health status						
Adolescents	Cross-sectional	0	1 (1)	NA: no studies	Decrease	Low
All adults	Cross-sectional	2 (2)	1 (1)	Decrease	No difference	Low
Health status and quality of life						
Elderly persons	Cohort	0	1 (1)	Decrease	Decrease	Moderate
	Cross-sectional	1 (0)	5 (4)			
Specific diseases	Cross-sectional	2 (0)	7 (7)	No difference	Inconsistent	Insufficient
Mental and physical functioning: elderly persons	Cohort	0	3 (2)	NA: no studies	Inconsistent	Insufficient
	Cross-sectional		2 (2)			
Healthy lifestyle (physical activity, eating habits, and seat belt use)	Cross-sectional	0	5 (4; for some outcomes)	NA: no studies	Inconsistent	Insufficient
HIV risk and sexual behavior	Cohort	0	1 (1)	NA: no studies	Inconsistent	Insufficient
	Cross-sectional	0	2 (2)			
HIV severity and symptoms	Cohort	3 (0)	1 (1)	Inconsistent	No difference in 4 studies	Low
	Cross-sectional		4 (3)			
Hospitalization	Cohort	2 (2)	4 (3)	Increase	Increase	Moderate
	Cross-sectional	0	2 (2)			
Hypertension control	Cross-sectional	1 (1)	2 (2)	No difference	Inconsistent	Insufficient
Immunization	Cohort	0	1 (1)	Decrease	Decrease	Moderate
	Cross-sectional	1 (1)	3 (3)			
Pneumococcal	Cohort	0	1 (1)	Decrease	Inconsistent	Insufficient
	Cross-sectional	1 (1)	1 (1)			
Interpreting labels and health messages	Cross-sectional	0	5 (4)	NA: no studies	Decrease	Moderate
Knowledge	Cohort	1 (0)	NA	Decrease	NA: analysis not repeated	Not re-evaluated
	Cross-sectional	9 (7)				
Mammography	Cross-sectional	1 (1)	4 (4)	Decrease	Decrease	Moderate
Mental health symptoms	Cohort	1 (0)	2 (1)	Decrease	Greater in 8 studies	Low
	Cross-sectional	4 (2)	8 (4)			
Mortality: elderly persons	Cohort	0	3 (3)	NA: no studies	Increase	High
Obesity and weight	Cohort	0	1 (0)	NA: no studies	Inconsistent	Insufficient
	Cross-sectional	0	4 (1)			
Pap tests	Cross-sectional	1 (1)	3 (3)	Decrease	Decrease	Low
Prostate cancer control	Cross-sectional	1 (1)	1 (1)	No difference	Decrease	Low
Review of prescription information	Cross-sectional	0	1 (1)	NA: no studies	Decrease	Low
Self-efficacy	Cross-sectional	0	6 (5)	NA: no studies	Inconsistent	Insufficient

*Continued on following page*

Table 2—Continued

Outcome	Study Design	Articles (Articles Controlling for Confounding), n (n)		Low vs. Adequate Health Literacy		Strength of Evidence: 2011
		2004	2011	2004	2011	
Smoking	Cross-sectional	3 (1)	2 (2)	Inconsistent	Inconsistent	Insufficient
STD (testing)	Cross-sectional	1 (1)	1 (1)	Increase	Increase	Low
Taking medications appropriately	Cohort	0	1 (1)	NA: no studies	Decrease	Moderate
	Cross-sectional	0	5 (5)			
Costs	Cohort	1 (1)	2 (2)	No difference	Inconsistent	Insufficient
Disparities	Cohort	0	1 (1)	Health literacy mediates racial disparity in 1 study	Health literacy partially mediates racial disparities in some outcomes; no differences in ethnicity; and sex differences for 1 outcome	Race, ethnicity, and sex: low
	Cross-sectional	1 (1)	5 (5)			

NA = not applicable; Pap = Papanicolaou; STD = sexually transmitted disease.

less likely to look at auxiliary labels (34). Another study found that persons with low health literacy were less likely to understand nutrition labels (35). In a third study, mothers with low literacy in Nepal had poorer ability to give an organized health narrative (36).

**Disease Prevalence and Severity**

*Mental Health Outcomes.* Although 8 of 10 studies found that patients with low health literacy were more likely to have symptoms of depression or to be considered depressed, we judged the strength of evidence as low (14, 19, 26, 37–43). Despite the general consistency of results, only 1 depression study rigorously controlled for potential confounders. In our earlier review, studies evaluating depression were inconsistent (7).

*Severity and Symptoms of HIV Infection.* Studies concerning HIV infection severity and health literacy were judged as low strength of evidence because most included limited control for confounding and had small sample sizes. Four studies (1 unadjusted) did not find differences in HIV infection severity by health literacy (19, 40, 44,

45). In contrast, low health literacy was associated with less intensity of symptoms in 1 study that controlled only for Hispanic ethnicity (38). Our earlier review, limited to unadjusted analyses, found inconsistent results (7).

**Global Health Status of Elderly Persons**

Five studies found poorer health status among elderly persons with low health literacy (18, 22, 25, 26, 46–49); we judged the evidence to be moderate. Studies included 1 good-quality, nationally representative sample (22); patients in Chicago, Illinois (18, 47); Prudential Medicare managed care enrollees (25, 48); and elderly persons in Korea (46). Two unadjusted analyses—one of elderly persons in Pittsburgh, Pennsylvania, and in Memphis, Tennessee (26), and a second of the Prudential Medicare sample that was included in our 2004 review (49)—also found the same result.

**Death**

Higher all-cause mortality rates of elderly persons were related to lower health literacy in 2 large, good-quality

Table 3. Numeracy Outcome Results: Strength of Evidence and Summary of Findings, 2011\*

Outcome	Study Design	Articles (Articles Controlling for Confounding), n (n)	Low vs. Adequate Numeracy	Strength of Evidence
Accuracy of risk perception	Cross-sectional	6 (4)	Inconsistent	Insufficient
Behavior	Cross-sectional	1 (0)	No difference	Insufficient
Disease prevalence and severity	Cross-sectional	5 (4)	Inconsistent	Insufficient
Knowledge	Cross-sectional	5 (4)	Inconsistent	Insufficient
Self-efficacy	Cross-sectional	3 (0)	Decrease	Low
Skills	Cohort	1 (1)	Taking medication (n = 4): inconsistent Interpretation of health information (n = 2): decrease	Taking medication: insufficient Interpretation of health information: low
	Cross-sectional	5 (4)		
Quality of life	Cross-sectional	1 (1)	Decrease	Low
Use of health care services	Cross-sectional	2 (2)	Inconsistent	Insufficient
Disparities	Cross-sectional	3 (3)	Numeracy partially mediates relationship between race and 2 outcomes and between sex and 1 outcome	Low

\* Numeracy studies were not included in the 2004 review.

studies, after participants' demographic characteristics, health status, and other factors were controlled for; strength of evidence was high (48, 50, 51). The inadequate health literacy group in the Prudential Medicare sample had higher mortality rates than the adequate health literacy group, after cognitive functioning (hazard ratio, 1.27 [95% CI, 1.03 to 1.57]) (50) and baseline measures of disease, physical functioning, and healthy lifestyle (hazard ratio, 1.52 [CI, 1.26 to 1.83]) were controlled for (48). Elderly persons with limited health literacy in the Pittsburgh and Memphis sample also had higher all-cause mortality rates (hazard ratio, 1.75 [CI, 1.27 to 2.41]) (51).

#### **Additional Outcomes: Low or Insufficient Evidence**

We judged the evidence of a relationship between health literacy and the following outcomes as insufficient because of inconsistent results: access to care (13, 14, 19, 23, 26, 52–57), self-efficacy (19, 58–61), various health behaviors (18, 19, 26, 35, 48, 57, 62–70), adherence to medication regimens and procedures (18, 19, 40, 44, 58, 71–82), prevalence of chronic disease (35, 48, 83), prevalence of specific diseases (14, 26, 46, 84), asthma severity and control (17, 21), dental disease (57, 85), diabetes control and complications (42, 86–89), hypertension control (90, 91), health-related quality of life among elderly persons (25, 46–48, 84), and health status among adults with specific diseases (38, 56, 92–96).

We graded the evidence as low when it consisted of few studies or unadjusted analyses. Outcomes included colorectal screening (18, 23, 59, 97, 98), Papanicolaou screening (18, 23, 99), acceptance of HIV testing (100), access to health insurance (101), seeking health-related information (102), asthma self-care (16), diabetes self-management (103), review of prescription information (104), prostate cancer control (105), and adult (106) and adolescent (69) health status.

#### **Potential Mediators and Moderators of the Effect of Health Literacy**

Mediators in the causal pathway between health literacy and health outcomes are factors that explain all or part of the relationship. Knowledge, patient self-efficacy, norms, and stigma may mediate the association between health literacy and at least some outcomes, such as adherence and diabetes control (40, 56, 58, 72, 73, 77, 89).

Moderators affect the magnitude or direction of a relationship. Social support and characteristics of the health care system may moderate the relationship between health literacy and both adherence and blood pressure control (76, 77, 90).

#### **Costs of Health Care**

Two studies about differences in costs of health care by health literacy level found inconsistent results (insufficient strength of evidence) (14, 107). The studies examined different payment sources (Medicaid and Medicare)

and services. Our earlier review found no relationship between literacy and Medicaid costs (108).

#### **Disparities in Use of Health Care Services or Health Outcomes**

Eight studies examined whether health literacy mediates disparities in use of health care services or health outcomes (109). One study examined whether health literacy moderates disparities.

Health literacy mediated disparities between white and black participants for many health outcomes; however, we judged the evidence as low because only 1 study examined each outcome, and findings from 1 outcome cannot be generalized to other outcomes that have not been tested. Outcomes include the inability to work because of a long-term illness or health condition (83), health status and influenza vaccination among elderly persons (22), physical and mental health domains of quality of life among Medicare enrollees (25), prostate-specific antigen levels among patients with newly diagnosed prostate cancer (105), non-adherence to HIV medication regimens (72), lack of health insurance for children (101), and misinterpretation of medication labels (110). Health literacy did not mediate racial disparities in mammography screening or dental checkups (22), glycemic control (111), parents' difficulty in understanding labels of over-the-counter medications (22, 101), or vaccination rates among elderly persons (25).

We also judged the evidence as low concerning health literacy as a mediator of outcome differences between ethnicities or genders; only 1 study was available to answer each question. Health literacy was not found to mediate differences in health status between Hispanic and white participants (22). In contrast, health literacy explained gender differences in interpreting medication label instructions (110).

In 1 study, health literacy was not found to be a moderator of disparities in health outcomes. The relationship between mortality and health literacy did not differ for black and white persons or for males and females (51).

#### **Relationship Between Numeracy and Outcomes**

Twenty-two studies examined the relationship between numeracy and various outcomes, including use of health care services, health, and disparities. No studies addressed differences in costs.

Two studies examined differences in use of health care services (breast and colorectal cancer screening) by numeracy level and found inconsistent results (insufficient strength of evidence) (112, 113).

In relation to health outcomes, we judged 3 outcomes as low evidence. Poorer self-efficacy in managing asthma and diabetes was related to poor numeracy in 3 studies (114–116). Similarly, less skill in interpreting health information (nutrition labels and health plan information) was related to poor numeracy in 2 studies (only 1 adjusted for potential confounders) (35, 54). One study found that poorer asthma-specific quality of life was related to poor

numeracy; the relationship was mediated by self-efficacy (115).

The relationship between numeracy and other outcomes was judged as insufficient; findings either were inconsistent or were supported by only 1 unadjusted analysis. These outcomes included accuracy of risk perception (11, 117–119, 131), knowledge (32, 112, 114, 120, 121), skills in taking medications (28, 30, 32, 35, 54, 122, 123), self-management behavior (114), and disease prevalence and severity (35, 65, 103, 114, 116).

The evidence of numeracy mediating disparities was low and was limited to racial differences in glycemic control (111) and medication management (123) and gender differences in medication management (28).

## DISCUSSION

Our updated review expands findings from the 2004 review in important ways. The 2004 review concluded that low health literacy was associated with poorer health-related knowledge and comprehension. The update shows that low health literacy is also associated with differential use of certain health care services, including increased hospitalizations and emergency care and decreased mammography screening and influenza immunizations. Differences in health-related outcomes include a poorer ability to demonstrate taking medications properly and interpret medication labels and health messages and, among elderly persons, poorer overall health status and higher mortality. Evidence is emerging that lower health literacy can mediate (explain or partially explain) racial disparities in health outcomes. The effect was demonstrated across several studies, each measuring a different outcome. In contrast, we did not find a relationship between health literacy and costs or other types of disparities. In both cases, only a few studies examined these relationships. Similarly, the body of evidence concerning the relationship between low numeracy and outcomes is very new and still inconclusive. A broader evidence base is needed to understand this relationship, including the relative importance of the print literacy and numeracy aspects of health literacy.

Newer studies addressed many of the methodological concerns identified in our previous review. Most important, the majority of studies in our updated review evaluated outcome differences by using multivariate analyses that controlled for potential confounding variables. These techniques produced less biased and more meaningful estimates of the direction and magnitude of the relationship between health literacy and outcomes. However, the final selection of confounding variables differed across studies, making synthesis of the literature difficult. Because studies were conducted in various settings and measured different outcomes, this may be appropriate to some extent. Many studies, however, controlled for educational attainment (which is highly correlated with health literacy), and some controlled for variables that would be expected to be in the

causal pathway or to mediate the relationship between health literacy and outcomes. This “overadjustment” may underestimate the effect of health literacy (124).

Studies are beginning to identify and isolate variables that can mediate the relationship between health literacy and outcomes. Important explanatory factors include health-related knowledge, self-efficacy, and beliefs (such as stigma related to one’s disease). Including control variables based on an analytic framework or causal model in future research would help clarify the pathway of effect between health literacy and health outcomes.

Because no gold standard exists for measuring health literacy, studies differ not only in the tools used but also in specifications of thresholds for distinguishing between health literacy levels. We found only sporadic evidence of differences between an occasionally measured middle category of health literacy and adequate health literacy. Early evidence suggests that the threshold level at which limited health literacy is negatively related to a health outcome may differ across outcomes (125). In future research, justification for the choices of health literacy thresholds based on the outcomes examined would lead to evidence that more meaningfully describes differences and thus identifies populations that are appropriate for different interventions.

Findings from our review can be considered in light of 4 other recent reviews that examined the relationship between health literacy and health outcomes. Each focused on a narrower patient population and settings and fewer outcomes, specifically children (evaluating their health literacy or that of their parents or caregivers) (126, 127), ambulatory care patients (128), and working-age adults (129). Their findings were generally similar to ours, including low health literacy being related to less health-related knowledge and poorer health status but were inconsistent regarding the relationship between low health literacy and overall use of health care services, overall health behavior, and disease severity. Another recent systematic review found, as we did, a mixed relationship between low health literacy and cost (130).

Given these and our reviews, we believe it is unlikely that we missed any meaningful body of work. Many published studies report no relationship between health literacy and outcomes, making selective reporting unlikely. Also, although we restricted our review to English-language articles, we found a growing body of literature that measured participants’ health literacy in languages other than English.

Although the field has made advances, work remains to be done. Limited data were available from nationally representative or other large samples. Moreover, many studies were conducted in just 1 clinic or in other narrowly defined patient populations. Some smaller studies may have lacked sufficient statistical power to detect differences among health literacy levels or selected uncommon health literacy thresholds because of limitations in their sample distribution. Therefore, larger studies and those that would add to

our confidence in the applicability of the evidence to a broader population are needed.

Regardless of these limitations, our updated review should enhance the public's awareness that low health literacy can play a substantial role in the interrelationship among patient characteristics, use of health care services, and resulting health outcomes. Finding ways to reduce the effects of low health literacy on health outcomes warrants the attention of policymakers, clinicians, and other stakeholders.

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## References

1. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Viera A, Crotty K, et al. Health Literacy Interventions and Outcomes: An Update of the Literacy and Health Outcomes Systematic Review of the Literature. Evidence Report/Technology Assessment no. 199. (Prepared by RTI International–University of North Carolina Evidence-based Practice Center under contract 290-2007-10056-1.) Rockville, MD: Agency for Healthcare Research and Quality; 2011.
2. Health literacy: report of the Council on Scientific Affairs. Ad Hoc Committee on Health Literacy for the Council on Scientific Affairs, American Medical Association. *JAMA*. 1999;281:552-7. [PMID: 10022112]
3. Baker DW. The meaning and the measure of health literacy. *J Gen Intern Med*. 2006;21:878-83. [PMID: 16881951]
4. Kutner M, Greenberg E, Jin Y, Paulsen C. The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy (NCES 2006-483). Washington, DC: U.S. Department of Education, National Center For Education Statistics; 2006.

5. Institute of Medicine. Report Brief. Health Literacy: A Prescription to End Confusion. Washington, DC: National Academies Pr; 2004.
6. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. National Action Plan to Improve Health Literacy. Washington, DC: U.S. Department of Health and Human Services; 2010.
7. Berkman ND, DeWalt DA, Pignone MP, Sheridan SL, Lohr KN, Lux L, et al. Literacy and Health Outcomes. Evidence Report Technology Assessment no. 87 (Prepared by the RTI International–University of North Carolina Evidence-based Practice Center under contract 290-02-0016.) Rockville, MD: Agency for Healthcare Research and Quality; 2004.
8. Owens DK, Lohr KN, Atkins D, Treadwell JR, Reston JT, Bass EB, et al. AHRQ series paper 5: grading the strength of a body of evidence when comparing medical interventions—agency for healthcare research and quality and the effective health-care program. *J Clin Epidemiol*. 2010;63:513-23. [PMID: 19595577]
9. Davis TC, Long SW, Jackson RH, Mayeaux EJ, George RB, Murphy PW, et al. Rapid estimate of adult literacy in medicine: a shortened screening instrument. *Fam Med*. 1993;25:391-5. [PMID: 8349060]
10. Parker RM, Baker DW, Williams MV, Nurss JR. The test of functional health literacy in adults: a new instrument for measuring patients' literacy skills. *J Gen Intern Med*. 1995;10:537-41. [PMID: 8576769]
11. Schwartz LM, Woloshin S, Black WC, Welch HG. The role of numeracy in understanding the benefit of screening mammography. *Ann Intern Med*. 1997;127:966-72. [PMID: 9412301]
12. Jastak S, Wilkinson G. Wide Range Achievement Test-Revised (WRAT-R). San Antonio, TX: The Psychological Corporation; 1984.
13. Baker DW, Gazmararian JA, Williams MV, Scott T, Parker RM, Green D, et al. Health literacy and use of outpatient physician services by Medicare managed care enrollees. *J Gen Intern Med*. 2004;19:215-20. [PMID: 15009775]
14. Howard DH, Gazmararian J, Parker RM. The impact of low health literacy on the medical costs of Medicare managed care enrollees. *Am J Med*. 2005;118:371-7. [PMID: 15808134]
15. Murray MD, Tu W, Wu J, Morrow D, Smith F, Brater DC. Factors associated with exacerbation of heart failure include treatment adherence and health literacy skills. *Clin Pharmacol Ther*. 2009;85:651-8. [PMID: 19262464]
16. Paasche-Orlow MK, Riekert KA, Bilderback A, Channugam A, Hill P, Rand CS, et al. Tailored education may reduce health literacy disparities in asthma self-management. *Am J Respir Crit Care Med*. 2005;172:980-6. [PMID: 16081544]
17. DeWalt DA, Dilling MH, Rosenthal MS, Pignone MP. Low parental literacy is associated with worse asthma care measures in children. *Ambul Pediatr*. 2007;7:25-31. [PMID: 17261479]
18. Cho YI, Lee SY, Arozullah AM, Crittenden KS. Effects of health literacy on health status and health service utilization amongst the elderly. *Soc Sci Med*. 2008;66:1809-16. [PMID: 18295949]
19. Murphy DA, Lam P, Naar-King S, Robert Harris D, Parsons JT, Muenz LR; Adolescent Medicine Trials Network for HIV/AIDS Interventions. Health literacy and antiretroviral adherence among HIV-infected adolescents. *Patient Educ Couns*. 2010;79:25-9. [PMID: 19665860]
20. Hope CJ, Wu J, Tu W, Young J, Murray MD. Association of medication adherence, knowledge, and skills with emergency department visits by adults 50 years or older with congestive heart failure. *Am J Health Syst Pharm*. 2004;61:2043-9. [PMID: 15509127]
21. Shone LP, Conn KM, Sanders L, Halterman JS. The role of parent health literacy among urban children with persistent asthma. *Patient Educ Couns*. 2009;75:368-75. [PMID: 19233588]
22. Bennett IM, Chen J, Soroui JS, White S. The contribution of health literacy to disparities in self-rated health status and preventive health behaviors in older adults. *Ann Fam Med*. 2009;7:204-11. [PMID: 19433837]
23. White S, Chen J, Atchison R. Relationship of preventive health practices and health literacy: a national study. *Am J Health Behav*. 2008;32:227-42. [PMID: 18067463]
24. Guerra CE, Krumholz M, Shea JA. Literacy and knowledge, attitudes and behavior about mammography in Latinas. *J Health Care Poor Underserved*. 2005;16:152-66. [PMID: 15741716]
25. Howard DH, Sentell T, Gazmararian JA. Impact of health literacy on socioeconomic and racial differences in health in an elderly population. *J Gen Intern Med*. 2006;21:857-61. [PMID: 16881947]
26. Sudore RL, Mehta KM, Simonsick EM, Harris TB, Newman AB, Satterfield S, et al. Limited literacy in older people and disparities in health and health-



- care access. *J Am Geriatr Soc*. 2006;54:770-6. [PMID: 16696742]
27. Kripalani S, Henderson LE, Chiu EY, Robertson R, Kolm P, Jacobson TA. Predictors of medication self-management skill in a low-literacy population. *J Gen Intern Med*. 2006;21:852-6. [PMID: 16881946]
  28. Waldrop-Valverde D, Jones DL, Jayaweera D, Gonzalez P, Romero J, Ownby RL. Gender differences in medication management capacity in HIV infection: the role of health literacy and numeracy. *AIDS Behav*. 2009;13:46-52. [PMID: 18618237]
  29. Raehl CL, Bond CA, Woods TJ, Patry RA, Sleeper RB. Screening tests for intended medication adherence among the elderly. *Ann Pharmacother*. 2006;40:888-93. [PMID: 16595567]
  30. Estrada CA, Martin-Hryniewicz M, Peek BT, Collins C, Byrd JC. Literacy and numeracy skills and anticoagulation control. *Am J Med Sci*. 2004;328:88-93. [PMID: 15311167]
  31. Yin HS, Mendelsohn AL, Wolf MS, Parker RM, Fierman A, van Schaick L, et al. Parents' medication administration errors: role of dosing instruments and health literacy. *Arch Pediatr Adolesc Med*. 2010;164:181-6. [PMID: 20124148]
  32. Yin HS, Dreyer BP, Foltin G, van Schaick L, Mendelsohn AL. Association of low caregiver health literacy with reported use of nonstandardized dosing instruments and lack of knowledge of weight-based dosing. *Ambul Pediatr*. 2007;7:292-8. [PMID: 17660100]
  33. Davis TC, Wolf MS, Bass PF 3rd, Thompson JA, Tilson HH, Neuberger M, et al. Literacy and misunderstanding prescription drug labels. *Ann Intern Med*. 2006;145:887-94. [PMID: 17135578]
  34. Wolf MS, Davis TC, Shrank W, Rapp DN, Bass PF, Connor UM, et al. To err is human: patient misinterpretations of prescription drug label instructions. *Patient Educ Couns*. 2007;67:293-300. [PMID: 17587533]
  35. Rothman RL, Housam R, Weiss H, Davis D, Gregory R, Gebretsadik T, et al. Patient understanding of food labels: the role of literacy and numeracy. *Am J Prev Med*. 2006;31:391-8. [PMID: 17046410]
  36. LeVine RA, LeVine SE, Rowe ML, Schnell-Anzola B. Maternal literacy and health behavior: a Nepalese case study. *Soc Sci Med*. 2004;58:863-77. [PMID: 14672599]
  37. Lincoln A, Paasche-Orlow MK, Cheng DM, Lloyd-Travaglini C, Caruso C, Saitz R, et al. Impact of health literacy on depressive symptoms and mental health-related: quality of life among adults with addiction. *J Gen Intern Med*. 2006;21:818-22. [PMID: 16881940]
  38. Nokes KM, Coleman CL, Cashen M, Dole P, Sefcik E, Hamilton MJ, et al. Health literacy and health outcomes in HIV seropositive persons. *Res Nurs Health*. 2007;30:620-7. [PMID: 18022832]
  39. Bennett IM, Culhane JF, McCollum KF, Mathew L, Elo IT. Literacy and depressive symptomatology among pregnant Latinas with limited English proficiency. *Am J Orthopsychiatry*. 2007;77:243-8. [PMID: 17535122]
  40. Kalichman SC, Pope H, White D, Cherry C, Amaral CM, Swetzes C, et al. Association between health literacy and HIV treatment adherence: further evidence from objectively measured medication adherence. *J Int Assoc Physicians AIDS Care (Chic)*. 2008;7:317-23. [PMID: 19056866]
  41. Walker D, Adebajo A, Heslop P, Hill J, Firth J, Bishop P, et al. Patient education in rheumatoid arthritis: the effectiveness of the ARC booklet and the mind map. *Rheumatology (Oxford)*. 2007;46:1593-6. [PMID: 17767002]
  42. Morris NS, MacLean CD, Littenberg B. Literacy and health outcomes: a cross-sectional study in 1002 adults with diabetes. *BMC Fam Pract*. 2006;7:49. [PMID: 16907968]
  43. Coffman MJ, Norton CK. Demands of immigration, health literacy, and depression in recent Latino immigrants. *Home Health Care Management & Practice*. 2010;22:116-22.
  44. Paasche-Orlow MK, Cheng DM, Palepu A, Meli S, Faber V, Samet JH. Health literacy, antiretroviral adherence, and HIV-RNA suppression: a longitudinal perspective. *J Gen Intern Med*. 2006;21:835-40. [PMID: 16881943]
  45. Mayben JK, Kramer JR, Kallen MA, Franzini L, Lairson DR, Giordano TP. Predictors of delayed HIV diagnosis in a recently diagnosed cohort. *AIDS Patient Care STDS*. 2007;21:195-204. [PMID: 17428187]
  46. Kim SH. Health literacy and functional health status in Korean older adults. *J Clin Nurs*. 2009;18:2337-43. [PMID: 19583664]
  47. Lee SY, Arozullah AM, Cho YI, Crittenden K, Vicencio D. Health literacy, social support, and health status among older adults. *Educational Gerontology*. 2009;35:191-201.
  48. Baker DW, Wolf MS, Feinglass J, Thompson JA, Gazmararian JA, Huang J. Health literacy and mortality among elderly persons. *Arch Intern Med*. 2007;167:1503-9. [PMID: 17646604]
  49. Gazmararian JA, Baker DW, Williams MV, Parker RM, Scott TL, Green DC, et al. Health literacy among Medicare enrollees in a managed care organization. *JAMA*. 1999;281:545-51. [PMID: 10022111]
  50. Baker DW, Wolf MS, Feinglass J, Thompson JA. Health literacy, cognitive abilities, and mortality among elderly persons. *J Gen Intern Med*. 2008;23:723-6. [PMID: 18330654]
  51. Sudore RL, Yaffe K, Satterfield S, Harris TB, Mehta KM, Simonsick EM, et al. Limited literacy and mortality in the elderly: the health, aging, and body composition study. *J Gen Intern Med*. 2006;21:806-12. [PMID: 16881938]
  52. Lindau ST, Basu A, Leitsch SA. Health literacy as a predictor of follow-up after an abnormal Pap smear: a prospective study. *J Gen Intern Med*. 2006;21:829-34. [PMID: 16881942]
  53. Grubbs V, Gregorich SE, Perez-Stable EJ, Hsu CY. Health literacy and access to kidney transplantation. *Clin J Am Soc Nephrol*. 2009;4:195-200. [PMID: 19056617]
  54. Hibbard JH, Peters E, Dixon A, Tusler M. Consumer competencies and the use of comparative quality information: it isn't just about literacy. *Med Care Res Rev*. 2007;64:379-94. [PMID: 17684108]
  55. Mancuso CA, Rincon M. Asthma patients' assessments of health care and medical decision making: the role of health literacy. *J Asthma*. 2006;43:41-4. [PMID: 16448964]
  56. Mancuso CA, Rincon M. Impact of health literacy on longitudinal asthma outcomes. *J Gen Intern Med*. 2006;21:813-7. [PMID: 16881939]
  57. Miller E, Lee JY, DeWalt DA, Vann WF Jr. Impact of caregiver literacy on children's oral health outcomes. *Pediatrics*. 2010;126:107-14. [PMID: 20547644]
  58. Wolf MS, Davis TC, Osborn CY, Skripkauskas S, Bennett CL, Makoul G. Literacy, self-efficacy, and HIV medication adherence. *Patient Educ Couns*. 2007;65:253-60. [PMID: 17118617]
  59. Peterson NB, Dwyer KA, Mulvaney SA, Dietrich MS, Rothman RL. The influence of health literacy on colorectal cancer screening knowledge, beliefs and behavior. *J Natl Med Assoc*. 2007;99:1105-12. [PMID: 17987913]
  60. Torres RY, Marks R. Relationships among health literacy, knowledge about hormone therapy, self-efficacy, and decision-making among postmenopausal health. *J Health Commun*. 2009;14:43-55. [PMID: 19180370]
  61. von Wagner C, Semmler C, Good A, Wardle J. Health literacy and self-efficacy for participating in colorectal cancer screening: The role of information processing. *Patient Educ Couns*. 2009;75:352-7. [PMID: 19386461]
  62. Wolf MS, Gazmararian JA, Baker DW. Health literacy and health risk behaviors among older adults. *Am J Prev Med*. 2007;32:19-24. [PMID: 17184964]
  63. von Wagner C, Knight K, Steptoe A, Wardle J. Functional health literacy and health-promoting behaviour in a national sample of British adults. *J Epidemiol Community Health*. 2007;61:1086-90. [PMID: 18000132]
  64. Sharif I, Blank AE. Relationship between child health literacy and body mass index in overweight children. *Patient Educ Couns*. 2010;79:43-8. [PMID: 19716255]
  65. Huizinga MM, Beech BM, Cavanaugh KL, Elasy TA, Rothman RL. Low numeracy skills are associated with higher BMI. *Obesity (Silver Spring)*. 2008;16:1966-8. [PMID: 18535541]
  66. Paasche-Orlow MK, Clarke JG, Hebert MR, Ray MK, Stein MD. Educational attainment but not literacy is associated with HIV risk behavior among incarcerated women. *J Womens Health (Larchmt)*. 2005;14:852-9. [PMID: 16313213]
  67. Marteleto L, Lam D, Ranchhod V. Sexual behavior, pregnancy, and schooling among young people in urban South Africa. *Stud Fam Plann*. 2008;39:351-68. [PMID: 19248720]
  68. Needham HE, Wiemann CM, Tortolero SR, Chacko MR. Relationship between health literacy, reading comprehension, and risk for sexually transmitted infections in young women. *J Adolesc Health*. 2010;46:506-8. [PMID: 20413090]
  69. Chang LC. Health literacy, self-reported status and health promoting behaviours for adolescents in Taiwan. *J Clin Nurs*. 2011;20:190-6. [PMID: 20629822]
  70. Janisse HC, Naar-King S, Ellis D. Brief report: parent's health literacy among high-risk adolescents with insulin dependent diabetes. *J Pediatr Psychol*. 2010;35:436-40. [PMID: 19755494]
  71. Gazmararian JA, Kripalani S, Miller MJ, Echt KV, Ren J, Rask K. Factors associated with medication refill adherence in cardiovascular-related diseases: a focus on health literacy. *J Gen Intern Med*. 2006;21:1215-21. [PMID: 17105519]

72. Osborn CY, Paasche-Orlow MK, Davis TC, Wolf MS. Health literacy: an overlooked factor in understanding HIV health disparities. *Am J Prev Med.* 2007;33:374-8. [PMID: 17950402]
73. Waite KR, Paasche-Orlow M, Rintamaki LS, Davis TC, Wolf MS. Literacy, social stigma, and HIV medication adherence. *J Gen Intern Med.* 2008;23:1367-72. [PMID: 18563494]
74. Osborn CY, Davis TC, Bailey SC, Wolf MS. Health literacy in the context of HIV treatment: introducing the Brief Estimate of Health Knowledge and Action (BEHKA)-HIV version. *AIDS Behav.* 2010;14:181-8. [PMID: 19023653]
75. Gatti ME, Jacobson KL, Gazmararian JA, Schmotzer B, Kripalani S. Relationships between beliefs about medications and adherence. *Am J Health Syst Pharm.* 2009;66:657-64. [PMID: 19299373]
76. Johnson VR, Jacobson KL, Gazmararian JA, Blake SC. Does social support help limited-literacy patients with medication adherence? A mixed methods study of patients in the Pharmacy Intervention for Limited Literacy (PILL) study. *Patient Educ Couns.* 2010;79:14-24. [PMID: 19647967]
77. Graham J, Bennett IM, Holmes WC, Gross R. Medication beliefs as mediators of the health literacy-antiretroviral adherence relationship in HIV-infected individuals. *AIDS Behav.* 2007;11:385-92. [PMID: 17053858]
78. Fang MC, Machtinger EL, Wang F, Schillinger D. Health literacy and anticoagulation-related outcomes among patients taking warfarin. *J Gen Intern Med.* 2006;21:841-6. [PMID: 16881944]
79. Chew LD, Bradley KA, Flum DR, Cornia PB, Koepsell TD. The impact of low health literacy on surgical practice. *Am J Surg.* 2004;188:250-3. [PMID: 15450829]
80. Hironaka LK, Paasche-Orlow MK, Young RL, Bauchner H, Geltman PL. Caregiver health literacy and adherence to a daily multi-vitamin with iron regimen in infants. *Patient Educ Couns.* 2009;75:376-80. [PMID: 19395227]
81. Gerber BS, Cho YI, Arozullah AM, Lee SY. Racial differences in medication adherence: A cross-sectional study of Medicare enrollees. *Am J Geriatr Pharmacother.* 2010;8:136-45. [PMID: 20439063]
82. Kripalani S, Gatti ME, Jacobson TA. Association of age, health literacy, and medication management strategies with cardiovascular medication adherence. *Patient Educ Couns.* 2010;81:177-81. [PMID: 20684870]
83. Sentell TL, Halpin HA. Importance of adult literacy in understanding health disparities. *J Gen Intern Med.* 2006;21:862-6. [PMID: 16881948]
84. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. *Arch Intern Med.* 2005;165:1946-52. [PMID: 16186463]
85. Parker EJ, Jamieson LM. Associations between indigenous Australian oral health literacy and self-reported oral health outcomes. *BMC Oral Health.* 2010;10:3. [PMID: 20346124]
86. Tang YH, Pang SM, Chan MF, Yeung GS, Yeung VT. Health literacy, complication awareness, and diabetic control in patients with type 2 diabetes mellitus. *J Adv Nurs.* 2008;62:74-83. [PMID: 18352966]
87. Powell CK, Hill EG, Clancy DE. The relationship between health literacy and diabetes knowledge and readiness to take health actions. *Diabetes Educ.* 2007;33:144-51. [PMID: 17272800]
88. Schillinger D, Barton LR, Karter AJ, Wang F, Adler N. Does literacy mediate the relationship between education and health outcomes? A study of a low-income population with diabetes. *Public Health Rep.* 2006;121:245-54. [PMID: 16640146]
89. Mancuso JM. Impact of health literacy and patient trust on glycemic control in an urban USA population. *Nurs Health Sci.* 2010;12:94-104. [PMID: 20487332]
90. Powers BJ, Olsen MK, Oddone EZ, Thorpe CT, Bosworth HB. Literacy and blood pressure—do healthcare systems influence this relationship? A cross-sectional study. *BMC Health Serv Res.* 2008;8:219. [PMID: 18947408]
91. Pandit AU, Tang JW, Bailey SC, Davis TC, Bocchini MV, Persell SD, et al. Education, literacy, and health: mediating effects on hypertension knowledge and control. *Patient Educ Couns.* 2009;75:381-5. [PMID: 19442477]
92. Muir KW, Santiago-Turla C, Stinnett SS, Herndon LW, Allingham RR, Challa P, et al. Health literacy and vision-related quality of life. *Br J Ophthalmol.* 2008;92:779-82. [PMID: 18460538]
93. Johnston MV, Diab ME, Kim SS, Kirshblum S. Health literacy, morbidity, and quality of life among individuals with spinal cord injury. *J Spinal Cord Med.* 2005;28:230-40. [PMID: 16048141]
94. Hahn EA, Cella D, Dobrez DG, Weiss BD, Du H, Lai JS, et al. The impact of literacy on health-related quality of life measurement and outcomes in cancer outpatients. *Qual Life Res.* 2007;16:495-507. [PMID: 17091362]
95. Hahn EA, Du H, Garcia SF, Choi SW, Lai JS, Victorson D, et al. Literacy-fair measurement of health-related quality of life will facilitate comparative effectiveness research in Spanish-speaking cancer outpatients. *Med Care.* 2010;48:S75-82. [PMID: 20473208]
96. Zhang XH, Li SC, Fong KY, Thumboo J. The impact of health literacy on health-related quality of life (HRQoL) and utility assessment among patients with rheumatic diseases. *Value Health.* 2009;12 Suppl 3:S106-9. [PMID: 20586970]
97. Guerra CE, Dominguez F, Shea JA. Literacy and knowledge, attitudes, and behavior about colorectal cancer screening. *J Health Commun.* 2005;10:651-63. [PMID: 16278201]
98. Miller DP Jr, Brownlee CD, McCoy TP, Pignone MP. The effect of health literacy on knowledge and receipt of colorectal cancer screening: a survey study. *BMC Fam Pract.* 2007;8:16. [PMID: 17394668]
99. Garbers S, Chiasson MA. Inadequate functional health literacy in Spanish as a barrier to cervical cancer screening among immigrant Latinas in New York City. *Prev Chronic Dis.* 2004;1:A07. [PMID: 15670438]
100. Barragán M, Hicks G, Williams MV, Franco-Paredes C, Duffus W, del Rio C. Low health literacy is associated with HIV test acceptance. *J Gen Intern Med.* 2005;20:422-5. [PMID: 15963165]
101. Yin HS, Johnson M, Mendelsohn AL, Abrams MA, Sanders LM, Dreyer BP. The health literacy of parents in the United States: a nationally representative study. *Pediatrics.* 2009;124 Suppl 3:S289-98. [PMID: 19861483]
102. Shieh C, Broome ME, Stump TE. Factors associated with health information-seeking in low-income pregnant women. *Women Health.* 2010;50:426-42. [PMID: 20853218]
103. Hassan K, Heptulla RA. Glycemic control in pediatric type 1 diabetes: role of caregiver literacy. *Pediatrics.* 2010;125:e1104-8. [PMID: 20368322]
104. Wolf MS, Davis TC, Shrank WH, Neuberger M, Parker RM. A critical review of FDA-approved Medication Guides. *Patient Educ Couns.* 2006;62:316-22. [PMID: 16884888]
105. Wolf MS, Knight SJ, Lyons EA, Durazo-Arvizu R, Pickard SA, Arseven A, et al. Literacy, race, and PSA level among low-income men newly diagnosed with prostate cancer. *Urology.* 2006;68:89-93. [PMID: 16844451]
106. Smith JL, Haggerty J. Literacy in primary care populations: is it a problem? *Can J Public Health.* 2003;94:408-12. [PMID: 14700237]
107. Weiss BD, Palmer R. Relationship between health care costs and very low literacy skills in a medically needy and indigent Medicaid population. *J Am Board Fam Pract.* 2004;17:44-7. [PMID: 15014052]
108. Weiss BD, Blanchard JS, McGee DL, Hart G, Warren B, Burgoon M, et al. Illiteracy among Medicaid recipients and its relationship to health care costs. *J Health Care Poor Underserved.* 1994;5:99-111. [PMID: 8043732]
109. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* 1986;51:1173-82. [PMID: 3806354]
110. Bailey SC, Pandit AU, Yin S, Federman A, Davis TC, Parker RM, et al. Predictors of misunderstanding pediatric liquid medication instructions. *Fam Med.* 2009;41:715-21. [PMID: 19882395]
111. Osborn CY, Cavanaugh K, Wallston KA, White RO, Rothman RL. Diabetes numeracy: an overlooked factor in understanding racial disparities in glycemic control. *Diabetes Care.* 2009;32:1614-9. [PMID: 19401443]
112. Aggarwal A, Speckman JL, Paasche-Orlow MK, Roloff KS, Battaglia TA. The role of numeracy on cancer screening among urban women. *Am J Health Behav.* 2007;31 Suppl 1:S57-68. [PMID: 17931137]
113. Ciampa PJ, Osborn CY, Peterson NB, Rothman RL. Patient numeracy, perceptions of provider communication, and colorectal cancer screening utilization. *J Health Commun.* 2010;15 Suppl 3:157-68. [PMID: 21154091]
114. Cavanaugh K, Huizinga MM, Wallston KA, Gebretsadik T, Shintani A, Davis D, et al. Association of numeracy and diabetes control. *Ann Intern Med.* 2008;148:737-46. [PMID: 18490687]
115. Apter AJ, Wang X, Bogen D, Bennett IM, Jennings RM, Garcia L, et al. Linking numeracy and asthma-related quality of life. *Patient Educ Couns.* 2009;75:386-91. [PMID: 19217741]
116. Osborn CY, Cavanaugh K, Wallston KA, Rothman RL. Self-efficacy links health literacy and numeracy to glycemic control. *J Health Commun.* 2010;15 Suppl 2:146-58. [PMID: 20845200]
117. Sheridan SL, Pignone M. Numeracy and the medical student's ability to interpret data. *Eff Clin Pract.* 2002;5:35-40. [PMID: 11874195]
118. Sheridan SL, Pignone MP, Lewis CL. A randomized comparison of patients' understanding of number needed to treat and other common risk reduc-

- tion formats. *J Gen Intern Med.* 2003;18:884-92. [PMID: 14687273]
119. **Haggstrom DA, Schapira MM.** Black-white differences in risk perceptions of breast cancer survival and screening mammography benefit. *J Gen Intern Med.* 2006;21:371-7. [PMID: 16686816]
120. **Vavrus F.** Girls' schooling in Tanzania: the key to HIV/AIDS prevention? *AIDS Care.* 2006;18:863-71. [PMID: 17012074]
121. **Portnoy DB, Roter D, Erby LH.** The role of numeracy on client knowledge in BRCA genetic counseling. *Patient Educ Couns.* 2010;81:131-6. [PMID: 19854023]
122. **Lokker N, Sanders L, Perrin EM, Kumar D, Finkle J, Franco V, et al.** Parental misinterpretations of over-the-counter pediatric cough and cold medication labels. *Pediatrics.* 2009;123:1464-71. [PMID: 19482755]
123. **Waldrop-Valverde D, Osborn CY, Rodriguez A, Rothman RL, Kumar M, Jones DL.** Numeracy skills explain racial differences in HIV medication management. *AIDS Behav.* 2010;14:799-806. [PMID: 19669403]
124. **DeWalt DA, Pignone MP.** Reading is fundamental: the relationship between literacy and health [Editorial]. *Arch Intern Med.* 2005;165:1943-4. [PMID: 16186462]
125. **Wolf MS, Feinglass J, Thompson J, Baker DW.** In search of 'low health literacy': threshold vs. gradient effect of literacy on health status and mortality. *Soc Sci Med.* 2010;70:1335-41. [PMID: 20167411]
126. **Geller J, Swetter SM, Leyson J, Miller DR, Brooks K, Geller AC.** Crafting a melanoma educational campaign to reach middle-aged and older men. *J Cutan Med Surg.* 2006;10:259-68. [PMID: 17241595]
127. **Sanders LM, Federico S, Klass P, Abrams MA, Dreyer B.** Literacy and child health: a systematic review. *Arch Pediatr Adolesc Med.* 2009;163:131-40. [PMID: 19188645]
128. **Kelly CM, Jorm AF, Wright A.** Improving mental health literacy as a strategy to facilitate early intervention for mental disorders. *Med J Aust.* 2007;187:S26-30. [PMID: 17908021]
129. **Easton P, Entwistle VA, Williams B.** Health in the "hidden population" of people with low literacy. A systematic review of the literature. *BMC Public Health.* 2010;10:459. [PMID: 20687946]
130. **Eichler K, Wieser S, Brügger U.** The costs of limited health literacy: a systematic review. *Int J Public Health.* 2009;54:313-24. [PMID: 19644651]

#### MANUSCRIPT PROCESSING AND TURNAROUND

*Annals* sends about half of submitted manuscripts for peer review and publishes about 10% of submitted material. The 2010 processing and notification turnaround time for manuscripts that were rejected without external peer review was within 1 week for more than 95% of submitted manuscripts. The processing and notification turnaround time for manuscripts that were received and rejected after external peer review was within 4 weeks for 50% and within 8 weeks for 98%.

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131. Davids SL, Schapira MM, McAuliffe TL, Nattinger AB. Predictors of pessimistic breast cancer risk perceptions in a primary care population. *J Gen Intern Med.* 2004;19:310-5. [PMID: 15061739]

132. Laramie AS, Morris N, Littenberg B. Relationship of literacy and heart failure in adults with diabetes. *BMC Health Serv Res.* 2007;7:98. [PMID: 17605784]

## Appendix Table 1. Search Strategy

Search Number, by Date and Database	Search Terms	Articles Returned, <i>n</i>
<b>May 2009</b>		
PubMed		
1	Numeracy	173
2	Numeracy; limits: Humans, English	146
3	"health literacy"	789
4	"health literacy"; limits: Entrez Date from 2003, Humans, English	586
5	#2 OR #4	716
6	Literacy	39 075
7	"rapid estimate functional health literacy" OR real*	215 538
8	#6 AND #7	920
9	"test of functional health literacy" OR tofhl*	295
10	#6 AND #9	295
11	"Hebrew health literacy test" OR HHLT	6
12	"medical achievement reading test" OR MART	1202
13	#6 AND #12	23
14	"newest vital signs" OR NVS	203
15	#6 AND #14	6
16	"short assessment of health literacy" OR SAHLSA	170
17	#6 AND #16	170
18	"wide range achievement test" OR WRAT	290
19	#6 AND #18	77
20	"nutritional literacy" OR "literacy assessment for diabetes" OR LAD OR SIL OR "single item numeracy screener" OR DAHL OR "demographic assessment" OR BEHKA OR "brief estimate" OR "diabetes numeracy" OR "medical data interpretation" OR "subjective numeracy" OR "numeracy test"	18 220
21	#6 AND #20	264
22	#8 OR #10 OR #11 OR #13 OR #15 OR #17 OR #19 OR #21	1661
23	#8 OR #10 OR #11 OR #13 OR #15 OR #17 OR #19 OR #21; limits: Entrez Date from 2003, Humans, English	729
24	#5 OR #23	1310
25	#5 OR #23; limits: Editorial, Letter, Case Reports	58
26	#24 NOT #25	1252
PubMed		
1	"rapid estimate of adult literacy"	104
2	"test of functional health literacy"	290
3	"Hebrew health literacy test"	6
4	"medical achievement reading test"	0
5	Medical achievements reading test	68
6	"newest vital signs"	1
7	"short assessment of health literacy"	170
8	"wide range achievement test"	219
9	"literacy assessment for diabetes"	225
10	"nutritional literacy"	3
11	"single item numeracy screener"	0
12	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11	991
13	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11; limits: Entrez Date from 2003, Humans, English	473
14	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11; limits: Entrez Date from 2003, Humans, Editorial, Letter, Case Report, English	5
15	#13 NOT #14	468
PubMed		
1	Literacy [tw]	5516
2	Literacy [tw]; limits: Entrez Date from 2003, Humans, English	2337
3	Literacy [tw]; limits: Editorial, Letter, Case Reports	243
4	#2 NOT #3	2226
CINAHL		
1	"health literacy"	34
Cochrane Library		
1	"health literacy"	61
PsycINFO		
1	"health literacy"	65
ERIC		
1	"health literacy"	34
Summary: Update, May 2009	Total unduplicated titles and abstracts through electronic database searches	2855

Continued on following page

**Appendix Table 1—Continued**

Search Number, by Date and Database	Search Terms	Articles Returned, <i>n</i>
<b>December 2009</b>		
PubMed		
1	Numeracy	213
2	Numeracy; limits: Human, English	169
3	"health literacy"	964
4	("2009/01/01"[Entrez Date]: "3000"[Entrez Date]) AND ("health literacy"); limits: Humans, English	110
5	#2 OR #4; limits: Humans, English	273
6	Literacy	41 096
7	"rapid estimate of adult literacy" OR real*	232 562
8	#6 AND #7	968
9	"test of functional health literacy" OR tofhl*	326
10	#6 AND #9	326
11	"Hebrew health literacy test" OR HHLT	7
12	"medical achievement reading test" OR MART	1300
13	#6 AND #12	26
14	"newest vital signs" OR NVS	220
15	#6 AND #14	8
16	"short assessment of health literacy" OR SAHLSA	187
17	#6 AND #16	187
18	"wide range achievement test" OR WRAT	302
19	#6 AND #18	83
20	"nutritional literacy" OR "literacy assessment for diabetes" OR LAD OR SIL OR "single item numeracy screener" OR DAHL OR "demographic assessment" OR BEHKA OR "brief estimate" OR "diabetes numeracy" OR "medical data interpretation" OR "subjective numeracy" OR "numeracy test"	18 849
21	#6 AND #20	282
22	#8 OR #10 OR #11 OR #13 OR #15 OR #17 OR #19 OR #21	1773
23	("2009/01/01"[Entrez Date]: "3000"[Entrez Date]) AND (#8 OR #10 OR #11 OR #13 OR #15 OR #17 OR #19 OR #21); limits: Humans, English	86
24	#5 OR #23	342
25	#5 OR #23; limits: Editorial, Letter, Case Reports	24
26	#24 NOT #25	318
CINAHL		
1	"health literacy"; limits: English, non-MEDLINE	37
2	"health literacy"; limits: 1/1/2009–12/31/2010, exclude MEDLINE records, English; search modes—Boolean/Phrase	37
Cochrane Library		
	"health literacy"; 2009–present	5
PsycINFO		
1	"health literacy"; 2009–present, English, no Editorials, no Letters	74
2	"health literacy"; limits: 1/1/2009–12/31/2010, English; search modes—Boolean/Phrase	74
ERIC		
1	"healthy literacy"; 2009–present, English	9
Summary: Update, December 2009	Total unduplicated titles and abstracts through electronic database searches	397
<b>May 2010</b>		
PubMed		
1	Numeracy	243
2	"health literacy"	1084
3	#1 OR #2	1285
4	Literacy	42 702
5	"rapid estimate of adult literacy" OR real*	245 476
6	#4 AND #5	1000
7	"test of functional health literacy" OR tofhl*	154
8	#4 AND #7	154
9	"Hebrew health literacy test" OR HHLT	1
10	#4 AND #9	1
11	"medical achievement reading test" OR MART	1358
12	#4 AND #11	28
13	"newest vital signs" OR NVS	261
14	#4 AND #13	11
15	"short assessment of health literacy" SAHLSA	49
16	#4 AND #15	49
17	"wide range achievement test" OR WRAT	303
18	#4 AND #17	84

*Continued on following page*

**Appendix Table 1—Continued**

Search Number, by Date and Database	Search Terms	Articles Returned, <i>n</i>
19	"nutritional literacy" OR "literacy assessment for diabetes" OR LAD OR SIL OR "single item numeracy screener" OR DAHL OR "demographic assessment" OR BEHKA OR "brief estimate" OR "diabetes numeracy" OR "medical data interpretation" OR "subjective numeracy" OR "numeracy test"	19 266
20	#4 AND #19	303
21	#6 OR #8 OR #10 OR #12 OR #14 OR #16 OR #18 OR #20	1522
22	#3 OR #21	2561
23	#22; limits: Humans, English	2042
24	#23; limits: Editorial, Letter, Case Reports	93
25	#23 NOT #24	1949
26	(#25) AND "20/10/01"[Entrez Date]: "3000"[Entrez Date]; sort by publication date	106
CINAHL		
1	Analogous terms were used to conduct searches	39
PsycINFO		
1	Analogous terms were used to conduct searches	68
Cochrane Library		
1	Analogous terms were used to conduct searches	44
ERIC		
1	Analogous terms were used to conduct searches	8
Summary: Update, May 2010	Total unduplicated titles and abstracts through electronic database searches	244
<b>December 2010</b>		
PubMed		
1	Numeracy	295
2	"health literacy"	1322
3	#1 OR #2	1563
4	Literacy	44 669
5	"rapid estimate of adult literacy" OR real*	262 208
6	#4 AND #5	1062
7	"test of functional health literacy" OR tofhl*	175
8	#4 AND #7	175
9	"Hebrew health literacy test" OR HHLT	1
10	#4 AND #9	1
11	"medical achievement reading test" OR MART	1433
12	#4 AND #11	28
13	"newest vital signs" OR NVS	281
14	#4 AND #13	12
15	"short assessment of health literacy" OR SAHLSA	56
16	"short assessment of health literacy" OR SAHL	306
17	#15 OR #16	306
18	#4 AND #17	56
19	"wide range achievement test" OR WRAT	314
20	#4 AND #19	86
21	"nutritional literacy" OR "literacy assessment for diabetes" OR LAD OR SIL OR "single item numeracy screener" OR DAHL OR "demographic assessment" OR BEHKA OR "brief estimate" OR "diabetes numeracy" OR "medical data interpretation" OR "subjective numeracy" OR "numeracy test"	19 820
22	#4 AND #21	319
23	#6 OR #8 OR #10 OR #12 OR #14 OR #18 OR #20 OR #22	1622
24	#3 OR #23	2896
25	#24; limits: Humans, English	2291
26	#24; limits: Editorial, Letter, Case Reports	121
27	#25 NOT #26	2180
28	(#27) AND "2010/03/01"[Entrez Date]: "3000"[Entrez Date] AND "0"[Entrez Date]: "3000"[Entrez Date]; sort by publication date	169
CINAHL		
1	"health literacy"; limits: English, non-MEDLINE	
2	"health literacy"; limits: 3/1/2010–12/07/2010; exclude MEDLINE records, English	
Summary: CINAHL, December 2010		54
Cochrane Library		
1	"health literacy"; limit: 2010–present	6
PsycINFO		
1	"health literacy"; limits: English, no Editorials, no Letters	
2	"health literacy"; limits: 3/1/2010–12/07/2010, English	

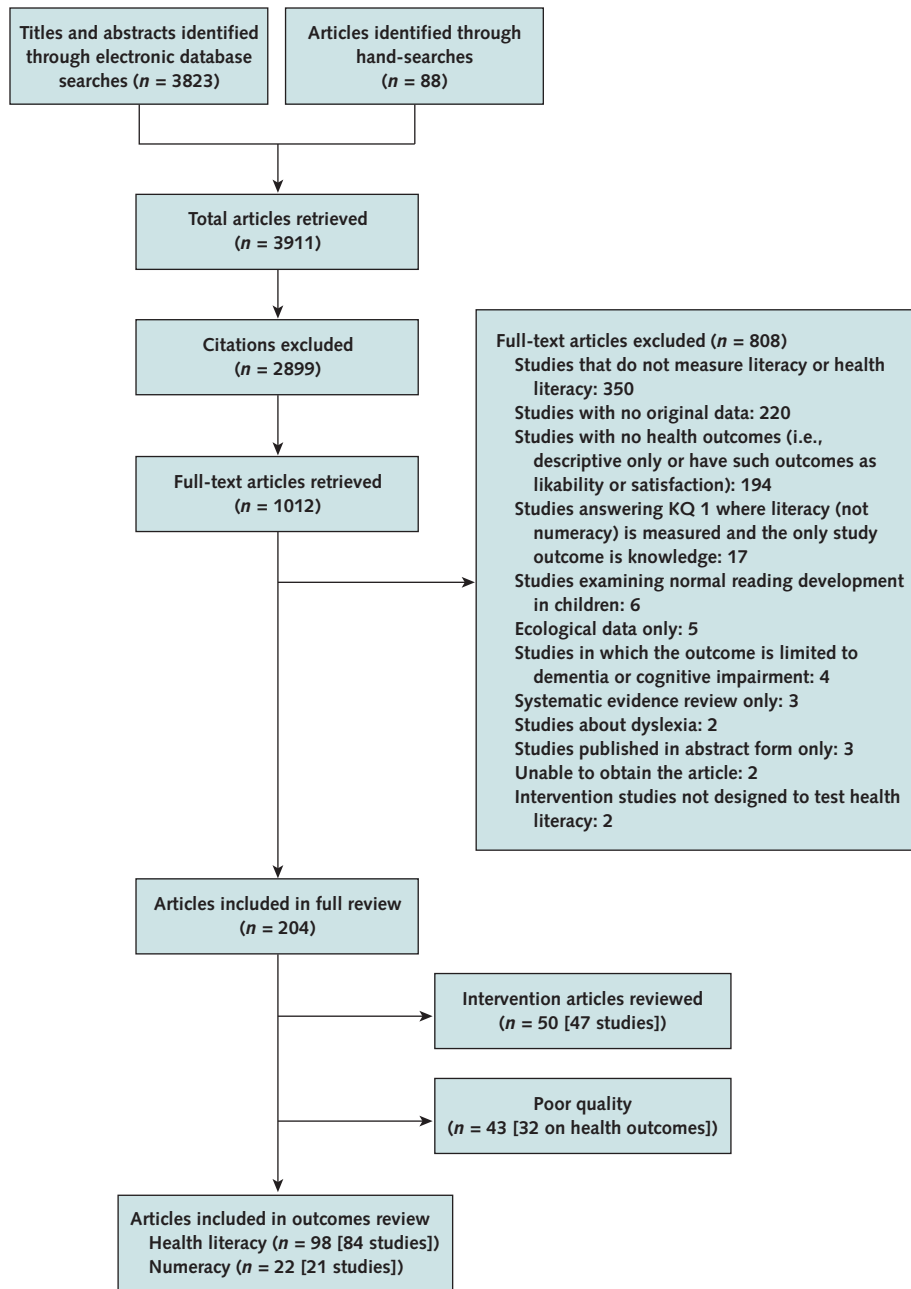
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**Appendix Table 1—Continued**

Search Number, by Date and Database	Search Terms	Articles Returned, <i>n</i>
Summary: PsycINFO, December 2010		51
ERIC		
1	"health literacy"; limits: 3/1/2010–12/07/2010, English	5
Summary: Update, December 2010	Total unduplicated titles and abstracts through electronic database searches	285
<b>February 2011</b>		
PubMed		
1	Numeracy	310
2	"health literacy"	1404
3	#1 OR #2	1656
4	Literacy	6982
5	"rapid estimate of adult literacy" OR real*	268 409
6	#4 AND #5	415
7	"test of functional health literacy" tofhl*	180
8	#4 AND #7	180
9	"Hebrew health literacy test" OR HHLT	1
10	#4 AND #9	1
11	"medical achievement reading test" OR MART	1833
12	#4 AND #11	7
13	"newest vital signs" OR NVS	288
14	#4 AND #13	10
15	"short assessment of health literacy" OR SAHLSA	56
16	SAHL	253
17	#15 OR #16	308
18	#4 AND #17	56
19	"wide range achievement test" OR WRAT	318
20	#4 AND #19	30
21	"nutritional literacy" OR "literacy assessment for diabetes" OR LAD OR SIL OR "single item numeracy screener" OR DAHL OR "demographic assessment" OR BEHKA OR "brief estimate" OR "diabetes numeracy" OR "medical data interpretation" OR "subjective numeracy" OR "numeracy test"	19 793
22	#4 AND #21	63
23	#6 OR #8 OR #10 OR #12 OR #14 OR #18 OR #20 OR #22	657
24	#3 OR #23	2021
25	#24; limits: Humans, English	1617
26	#24; limits: Editorial, Letter, Case Reports	117
27	#25 NOT #26	1511
28	#27 AND (2010/12:2011/02 [edat])	16
29	#25; limits: Published in the last 3 years	756
30	#29; limits: Review	80
31	#28 OR #30	95
CINAHL		
1	"health literacy"; limits: English, non-MEDLINE	
2	"health literacy"; limits: 12/2010–2/2011, English, exclude MEDLINE records	
Summary: CINAHL, February 2011		11
1	"health literacy"; 2010–present	4
PsycINFO		
1	"health literacy"; limits: English, Humans, no Editorials, no Letters	
2	"health literacy"; limits: 12/2010–2/2011, English	
Summary: PsycINFO, February 2011		21
ERIC		
1	"health literacy"; limits: 12/2010–2/2011, English	1
Summary: Update, February 2011		53



Appendix Figure. Summary of evidence search and selection.



KQ = key question.

**Appendix Table 2. Overview of Numeracy Studies**

Study, Year (Reference)	Design	Numeracy Instrument	Quality Score	Study Sample	Outcomes	Variables Used in Multivariate Analysis
Aggarwal et al, 2007 (112)	Cross-sectional	5-item test adapted from the Black-Toteson Numeracy Test	Fair	264 patients at 4 ambulatory care clinics affiliated with a U.S. urban academic medical center	Knowledge, use of health care services	Age, race, education, primary care provider, FH of disease
Apter et al, 2009 (115)	Cross-sectional	Asthma Numeracy Questionnaire	Fair	80 patients with moderate or severe asthma recruited from urban medical practices in Philadelphia	Quality of life, self-efficacy	Age, Latino ethnicity
Cavanaugh et al, 2008 (114)	Cross-sectional	WRAT-3, Diabetes Numeracy Test	Fair	398 patients from 2 primary care clinics and 2 endocrinology clinics at 3 U.S. hospitals	Knowledge (unadjusted), self-efficacy (unadjusted), behavior (unadjusted), disease severity	Age, sex, race, income, type of diabetes, years since diagnosis, clinic site
Ciampa et al, 2010 (113)	Cross-sectional	1 item from the Lipkus Numeracy Test	Fair	1436 participants in the Health Information Technology Survey	Use of health care services	Age, sex, race, income, education, health insurance
Dauids et al, 2004 (131)	Cross-sectional	Test adapted from the Schwartz-Woloshin Numeracy Test	Fair	254 patients in 2 U.S. academic general medicine clinics	Accuracy of risk perception	Age, race, education, income, FH of breast cancer, age at menses, age at first live birth, number of breast biopsies
Estrada et al, 2004 (30)	Prospective cohort	6 items (including 3 items adapted from the Schwartz-Woloshin Numeracy Test)	Fair	143 patients in anticoagulation management clinics in 1 U.S. university and 1 U.S. VA-based hospital	Medication management skills	Age
Haggstrom and Schapira, 2006 (119)	Cross-sectional	Schwartz-Woloshin Numeracy Test	Fair	207 patients in a general medicine clinic at a U.S. academic medical center	Accuracy of risk perception	Age, race, FH, family income, insurance, education
Hassan and Heptulla, 2010 (103)	Cross-sectional	Newest vital sign	Fair	200 parents or caregivers of children with diabetes receiving care at a U.S. diabetes clinic	Glycemic control	Race, language, income, education
Hibbard et al, 2007 (54)	RCT: data analyzed cross-sectionally	15-item scale adapted from the Lipkus Numeracy Test	Fair	303 community-dwelling U.S. adults	Skill (unadjusted), use of health care services (unadjusted)	None
Huizinga et al, 2008 (65)	Cross-sectional	WRAT-3	Fair	169 patients in a U.S. academic primary care clinic	Disease prevalence or severity	Age, sex, race, income, education, REALM
Lokker et al, 2009 (122)	Cross-sectional	WRAT math subtest	Fair	182 caregivers of patients at general pediatric clinics at 3 academic medical centers	Medication management skills	Age, sex, race, education
Osborn et al, 2009 (111)	Cross-sectional	Diabetes Numeracy Test	Good	383 patients at 2 primary care and 2 diabetes specialty clinics located at 3 medical centers	Disease prevalence and severity (numeracy as a mediator of relationship between race and HbA <sub>1c</sub> )	Age, year of diagnosis, diabetes, insulin use, African American
Osborn et al, 2010 (116)	Cross-sectional	WRAT math subtest	Fair	383 patients at 2 primary care and 2 diabetes specialty clinics located at 3 medical centers	Disease severity measured through glycemic control	Age, African American, years since diagnosis, insulin, diabetes self-efficacy
Portnoy et al, 2010 (121)	Cross-sectional	3-item test adapted from the Schwartz-Woloshin Numeracy Test	Fair	246 residents of Baltimore and Salt Lake City	Knowledge	Age, site, REAL-G (genetic testing literacy measure), session length
Rothman et al, 2006 (35)	Cross-sectional	WRAT-3	Fair	200 patients at 1 U.S. academic primary care clinic	Skill (unadjusted), disease prevalence or severity (unadjusted)	None
Schwartz et al, 1997 (11)	RCT: data analyzed cross-sectionally	Schwartz-Woloshin Numeracy Test	Fair	287 patients at a U.S. VA hospital who received a mailed survey	Accuracy of risk perception	Age, income, education, frame of information
Sheridan and Pignone, 2002 (117)	RCT: data analyzed cross-sectionally	Schwartz-Woloshin Numeracy Test	Fair	62 medical students in a U.S. medical school	Accuracy of risk perception (unadjusted)	None
Sheridan et al, 2003 (118)	RCT: data analyzed cross-sectionally	Schwartz-Woloshin Numeracy Test	Fair	357 patients in a U.S. academic general medicine clinic	Accuracy of risk perception (unadjusted)	None
Vavrus, 2006 (120)	Cross-sectional	Unspecified numeracy test	Fair	277 students from 4 school districts in Tanzania	Knowledge	Sex, literacy, household spending, parents' education, television in home, siblings, electricity, sewage
Waldrop-Valverde et al, 2009 (28)	Cross-sectional	Woodcock-Johnson Applied Problems subtest	Fair	155 patients at HIV clinics or participants in an AIDS drug-assistance program in Miami	Medication management skills (numeracy as a mediator of the relationship between sex and capacity to manage medications)	Sex, time since HIV diagnosis, education, health literacy

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**Appendix Table 2 —Continued**

Study, Year (Reference)	Design	Numeracy Instrument	Quality Score	Study Sample	Outcomes	Variables Used in Multivariate Analysis
Waldrope-Valverde et al, 2010 (123)	Cross-sectional	Woodcock–Johnson Applied Problems subtest	Fair	207 patients at HIV clinics or participants in an AIDS drug-assistance program in Miami	Medication management skills (numeracy as a mediator of the relationship between race and capacity to manage medications)	Female, African American, time since HIV diagnosis
Yin et al, 2007 (32)	Cross-sectional	TOFHLA numeracy subtest	Fair	292 caregivers of young children at the pediatric emergency department in a U.S. urban academic medical center	Knowledge, medication management skills	Caregiver education, country of origin, language, SES, age of children, regular health care provider, experience in health care setting

FH = family history; HbA<sub>1c</sub> = hemoglobin A<sub>1c</sub>; RCT = randomized, controlled trial; REAL-G = Rapid Estimate of Adult Literacy in Genetics; REALM = Rapid Estimate of Adult Literacy in Medicine; SES = socioeconomic status; TOFHLA = Test of Functional Health Literacy in Adults; VA = Veterans Affairs; WRAT-3 = Wide Range Achievement Test, 3rd edition.