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Evidence Report
Number XX

Health Literacy Interventions and Outcomes: An Update of the Literacy and Health Outcomes Systematic Review of the Literature

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-Based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review prior to their release.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

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Structured Abstract

Objectives. To update a 2004 systematic review of health service use and health outcomes related to differences in health literacy level and interventions designed to improve these outcomes for individuals with low health literacy. In this updated review, we expand our conception of health literacy to include both numeracy and oral literacy in addition to print literacy.

Data sources. We searched MEDLINE®, the Cumulative Index to Nursing and Allied Health (CINAHL), the Cochrane Library, PsychINFO, and the Educational Resources Information Center (ERIC) for relevant literature. For health literacy, we searched, from 2003 to March 2009 using a variety of terms. For numeracy, we searched from 1966 to March 2009. We limited both searches to English and human-only studies.

Review methods. We used standard Evidence-based Practice Center methods, including dual review of abstracts and full-text articles to determine article inclusion; and dual abstractions, quality ratings, and strength of evidence grading. We resolved disagreements by consensus. To aid intervention study interpretation, queries were sent to authors of intervention studies to obtain missing information about their interventions.

Results. We included good- and fair-quality studies: 68 addressing health outcomes and 33 addressing interventions. Most outcome studies had cross-sectional designs, but 15 were cohort studies. Across 33 intervention studies, 19 were randomized controlled trials (RCTs), 2 were cluster randomized trials, and 12 were quasi-experimental studies.

In outcome studies, differences in health literacy level were consistently associated with increased hospitalizations, greater emergency care use, lower receipt of influenza vaccine, poorer ability to interpret labels and health messages, greater probability of depressive symptoms, and, among seniors, lower quality of life, and higher mortality. Additionally, health literacy level potentially mediates disparities between black populations and health outcomes. Evidence for the relationship between numeracy level and many health outcomes (including accuracy of risk perception, knowledge, skills taking medication, and disease prevalence and severity) was mixed. However, evidence is emerging of a possible relationship between numeracy and disease-specific knowledge. Furthermore, lower numeracy level may lead to lower accuracy of perceived risk and treatment benefit, particularly if risk is presented over longer time frames (e.g., lifetime risks rather than 5-year risk) and if results reflect comparisons between those at the extremes of numeracy skill. Evidence for the relationship between numeracy and other health outcomes was insufficient to draw conclusions. We found no evidence concerning oral health literacy and outcomes.

With respect to interventions, 14 used one specific strategy to mitigate the effects of low health literacy, and 19 used a mixture of strategies combined into one intervention. Many newly identified single intervention strategies resulted in improved comprehension in one study; these included presenting only essential information; presenting essential information first; presenting quality information with the higher number indicating better quality; and presenting information in pictograms in grouped rather than random format. Additionally several studies reconsidered from our 2004 review suggest potential benefit from using reduced reading level, video, and/or illustrated narratives. Mixed interventions resulted in improvements in self-management behavior, disease prevalence and severity, preventive service utilization, emergency department visit rates, and hospitalizations. Mixed intervention effects on knowledge, self-efficacy,

adherence, and quality of life were mixed. Components of effective interventions were their high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional. Interventions that changed distal outcomes appeared to work by intermediately increasing knowledge or self-efficacy, or by changing behavior.

Conclusions. The field of health literacy has advanced since the 2004 report and provides additional insights into the impact of low health literacy and ways to intervene to reduce its effects. Future research priorities include standardizing definitions of health literacy levels, developing tools that measure additional related skills, and examining mediators and moderators of the effect of health literacy. Priorities in advancing intervention research include: additional testing of apparently effective interventions and newly testing novel approaches to increase motivation; improved techniques for delivering written, oral or numerical information; and "work around" interventions such as patient advocates.

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Executive Summary

Introduction

Health literacy is "the degree to which individuals can obtain, process, and understand the basic health information and services they need to make appropriate health decisions." It represents a constellation of skills necessary to function effectively in the health care environment and act appropriately on health care information. These skills include the ability to interpret documents, and read and write prose (print literacy), use quantitative information (numeracy), and speak and listen effectively (oral literacy). In a 2004 systematic evidence review, health literacy was associated with health-related knowledge and comprehension, hospitalization rates, global health measures, and some chronic diseases, such that those with lower health literacy had poorer outcomes.

Given the apparent relationship between health literacy level and poor health outcomes, and the potential to reduce poor outcomes using novel interventions, several national organizations have promoted health literacy as a research priority and researchers have responded with new work. To synthesize the increasing volume of literature on health literacy, AHRQ commissioned the RTI–UNC EPC to update its 2004 systematic review examining the effects of literacy on health outcomes and interventions to improve those outcomes. In this updated report, we focus on the same key questions as the original report, but we also expand our conception of health literacy to include numeracy and oral literacy. The specific questions of interest to us are:

> **Key Question 1.** Outcomes: Are health literacy skills related to (a) use of health care services, (b) health outcomes, (c) costs of health care, and (d) disparities in health outcomes or health care service use?
> **Key Question 2.** Interventions: For individuals with low health literacy skills, what are effective interventions to (a) improve use of health care services, (b) improve health outcomes, (c) affect the costs of care, and (d) improve health care service use and/or health outcomes among different racial, ethnic, cultural or age groups?

Methods

We searched MEDLINE®, the Cumulative Index to Nursing and Allied Health (CINAHL), the Cochrane Library, PsychINFO, and the Educational Resources Information Center (ERIC). For health literacy, we searched from 2003 to March 2009. For numeracy, we searched from 1966 to March 2009. We conducted key word searches because no MeSH headings specifically identify health literacy-related articles. The terms "health literacy," "numeracy," and "literacy," and terms or phrases related to instruments known to measure health literacy and numeracy were the focus of the search. Editorials, letters to the editor, and case reports were excluded. We also excluded non-English language and included human-only studies.

We used standard EPC methods of dual review of abstracts and full text of articles to determine article inclusion. We additionally used dual data abstraction for evidence tables, rating quality of articles, and grading strength of evidence. We rated the internal validity of studies as good, fair, or poor. We used the AHRQ EPC program's approach to grading strength of evidence as high, moderate, low, or insufficient. We resolved disagreements by consensus.

Our overall goals were to evaluate whether newer literature was appropriate for answering our key questions and to determine whether earlier conclusions changed. We modified the original methods as follows:

- We broadened our definition of health literacy to be consistent with the Ratzan and Parker (2000) definition used by Healthy People 2010 and the Institute of Medicine. Thus, we now include studies that evaluated the numeracy skills of participants. Our inclusion criteria also encompassed studies that used measures of oral (spoken) health literacy or other skills-based approaches to health literacy measurement, but we did not find any such published studies.
- We excluded intervention studies that did not measure health literacy directly.
- We required that studies directly measured the health literacy of the study population, did not conclude health literacy level via self-report or similarity to other populations.
- We modified criteria for evaluating individual study quality to incorporate advances in the methodology of conducting systematic reviews, including not using a numeric summary of individual criteria in determining the overall quality rating.
- We included studies conducted in developing countries as long as an objective measure of literacy or health literacy was measured directly in participants.
- If information was missing from articles about intervention studies, we queried the investigators to allow richer interpretation about what interventions may be effective in mitigating the effects of low health literacy.

Our initial search of electronic databases and manually searched reference lists of pertinent review articles and editorials produced 2,883 unduplicated records. Ultimately, for the two main questions, we included studies rated either good or fair quality: 68 studies addressed KQ 1 (in 81 articles on health literacy and 13 on numeracy, including 4 on both); 33 studies addressed KQ 2.

Results

Key Question 1: Relationship of Health Literacy to Various Outcomes and Disparities

Most outcome studies had cross-sectional designs, but 15 were cohort studies.We categorized studies examining outcomes associated with differences in health literacy level into two domains: use of health care services and health outcomes. Components of health care service use include: hospitalization, emergency care visits, colon screening, Papanicolau tests, mammography, testing for sexually transmitted infections, influenza immunization, pneumococcal immunization, and access to care. Health outcomes include: adherence, self-efficacy, smoking, alcohol use, healthy lifestyle (physical activity, eating habits, seatbelt use, obesity and weight), review of prescription information, HIV risks and sexual behaviors, taking medications appropriately, interpreting labels and health messages, asthma self-care, mental health, chronic disease prevalence, HIV severity and symptoms, asthma severity and control, diabetes control and related symptoms, hypertension control, prostate cancer control, health status, quality of life, mortality and costs.

Differences in health literacy level, comparing those in the lowest with those in the highest category, showed consistent associations between lower health literacy and the following patterns of service use or health outcomes:

- Increased hospitalizations (5 studies; moderate strength of evidence);
- Greater emergency care use (8 studies; moderate strength of evidence);
- Lower receipt of influenza vaccine (4 studies; moderate strength of evidence);
- Poorer ability to interpret labels and health messages (3 studies; moderate strength of evidence);
- Greater probability of depression or depressive symptoms (8 studies; moderate strength of evidence);
- Lower quality of life among seniors (4 studies; moderate strength of evidence);
- Higher mortality among seniors (2 studies; high strength of evidence).

The strength of evidence in relation to all other outcomes was graded as low because of such factors as inconsistent findings, a minimal amount of evidence, and/or individual studies with a high risk of bias. The evidence was sparse for evaluating differences between those with marginal (middle category) health literacy and adequate (the highest category).

Health literacy level potentially mediates the relationship between black race and health outcomes. This mediator effect was found in adjusted analyses comparing black and white respondents along various dimensions: in a national sample of adults with a condition that keeps them from working or a long-term illness; in a national sample of seniors, self-reported health status and receipt of an influenza vaccine; among seniors, physical and mental health-related quality of life and self-reported health; among newly diagnosed prostate patients, prostate-specific antigen levels; and among patients with HIV, nonadherence to HIV medications.

Key Question 1: Relationship of Numeracy to Various Outcomes and Disparities

In this update, we reviewed 13 studies that examined the relationship between numeracy and various outcomes, including use of health care services, health outcomes, costs, and disparities. Most studies examining the relationship of numeracy to health outcomes were cross-sectional in design. Four studies were randomized controlled trials (RCTs) that analyzed their data in a cross-sectional manner for this analysis; and one used a prospective cohort design.

In general, the strength of evidence for the relationship between numeracy and outcomes was insufficient or low given the small number of studies, which often had high levels of risk of bias or collectively gave us mixed results. Only two studies addressed the relationship between numeracy and use of health care services. These studies reached mixed results, likely due in part to high risk of bias with lack of adjustment for relevant confounders in one study and inadequate power in the other. Similarly, several studies demonstrated that the relationships between numeracy level and accuracy of risk perception (5 studies), knowledge (4 studies), skills taking medication (2 studies), and disease prevalence and severity (3 studies) are mixed. However, evidence is emerging of a possible relationship between numeracy and disease-specific knowledge. Furthermore, lower numeracy level may lead to lower accuracy of perceived risk and treatment benefit, particularly if risk is presented over longer time frames (e.g., lifetime risks rather than 5-year risk) and if results reflect comparisons between those at the extremes of numeracy skill. Evidence for the relationship between numeracy and other health outcomes (e.g. self-efficacy, behavior) was insufficient to draw conclusions. No studies addressed the costs associated with differences in numeracy level or whether numeracy level mediates health disparities.

Key Question 2: Interventions to Improve Low Health Literacy

With respect to interventions, 14 used one specific strategy to mitigate the effects of low health literacy, and 19 used a mixture of strategies combined into one intervention.

Interventions with single design features. In general, the strength of evidence regarding the effect of specific design features of interventions for low health literacy populations is low. This is attributable, in large part, to differences in the interventions (and subsequently results) for studies broadly grouped as follows: alternative document design, alternative numerical presentation, alternative pictorial representation, alternative media, alternative readability and document design, and physician notification of literacy status.

Looking closely within categories, we noted that several specific design features show promise in improving comprehension for low health literacy populations. These features, each of which was tested in only one study, include presenting only essential information, presenting essential information first, presenting quality information with the higher number indicating better quality, and presenting information in pictograms in grouped rather than random format. Additionally, re-examining data from our 2004 review within these categories further suggests potential benefit from using reduced reading level, video, and/or illustrated narratives. In contrast, one study raised questions about whether certain design features, such as colored traffic symbols to denote death rates in hospitals of varying quality or symbols accompanying nonessential quality information, may actually worsen health choices among those with low health literacy.

Interventions with combinations of features. The strength of evidence for studies combining multiple strategies to mitigate the effects of low health literacy on outcomes was more variable than for single-feature interventions. We found moderate strength of evidence that studied interventions change health care service use. Specifically, intensive self-management and adherence interventions appear to be effective in reducing emergency room visits and hospitalizations. Additionally, educational interventions and/or cues for screening increased colorectal cancer and prostate cancer screening. We note, however, that the health benefits of additional prostate cancer screening are questionable and that increased screening rates could be a marker for poor decisionmaking.

Evidence of moderate strength indicates that some interventions change health outcomes. For instance, intensive disease-management programs appear to be effective at reducing disease prevalence and severity. Furthermore, self-management interventions increased self-management behavior; in studies that performed subgroup analyses, however, the effect was greater in high health literacy populations than in lower literacy populations. The effects of other interventions on other health outcomes, including knowledge, self-efficacy, and quality of life, were mixed; thus, the strength of evidence was low.

Components of effective interventions were their high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional. Interventions that changed distal outcomes appeared to work by intermediately increasing knowledge or self-efficacy, or by changing behavior.

Too few studies addressed the effects of literacy interventions on the outcomes of behavioral intent, health-related skills, cost, and disparities to draw any meaningful conclusions; the strength of evidence is low.

Discussion

Our results expand findings from our 2004 review in numerous ways. First, unlike the earlier review, primary study outcomes were generally evaluated using multivariate analysis, providing a better and less biased estimate of the direction and magnitude of effect for our findings. Second, our review addresses the relationship between numeracy level and health outcomes. This addition expands our understanding of the skills that are needed to be health literate. Third, we found a limited body of research that begins to provide evidence of variables that may be on a causal pathway between health literacy and health outcomes; these include knowledge, self-efficacy, and beliefs such as stigma related to having HIV. Fourth, new studies suggest that health literacy can be a mediator of racial disparities in health outcomes.

Fifth, we confirmed several promising intervention design features that bear further study: presenting only essential information, essential information first, quality information with the higher number indicating better quality, and information in pictograms in grouped rather than random format and using reduced reading level, video, and/or illustrated narratives. Sixth, interventions focused on a broader range of outcomes; six studies examined the impact of interventions on three or more outcomes and preliminarily suggest that effective interventions to mitigate the effects of low health literacy may work by increasing knowledge, increasing self-efficacy, or changing behavior. Seventh, our findings help illuminate what factors may be key in making the interventions effective with respect to distal outcomes (e.g. self-management, hospitalizations, mortality); these include high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional (e.g., pharmacist, diabetes educator).

Limitations of the Literature

As with all systematic reviews, our results and conclusions depend on the quality of the published literature. A limitation across key questions was heterogeneity in outcomes, populations, and study designs; this level of diversity in the knowledge base precluded us from pooling results statistically.

Specific limitations of the literature for KQ 1 studies included the following: inconsistent approaches to creating health literacy and numeracy levels or thresholds in analyses, hampering comparisons between studies; inconsistent choice of potential confounding variables included in multivariate analyses; small sample sizes, making it impossible for us to determine whether null findings represented a true lack of effect or simply limitations in statistical power; studies in just one clinic or in other narrowly defined patient populations, rendering the applicability of findings to other settings or populations unknowable; use of health literacy tools that continue to focus primarily on reading ability; the limited number of studies examining potential mediators of health literacy, such as self-efficacy, knowledge, or beliefs; few studies examining the role of health literacy on health disparities; and no studies examining differences in outcomes related to oral literacy skills.

The limitations of the literature for KQ 2 studies included the following: lack of an adequate control or comparator group in many studies, limiting the ability to determine the true effect(s) of the intervention; measurement of multiple outcomes with insufficient attention to ensure that each is adequately powered to detect a difference; testing interventions that combined various design features to mitigate the effect of low health literacy but offering no way to determine the effectiveness of individual components; failure to perform adequately controlled subgroup

analyses that would elucidate differential effects of interventions in low- and high-health literacy populations; and failure to report adequately the intervention design features that would allow future content analyses of effective interventions.

Future Research

This update shows that the field of health literacy has advanced since our 2004 review. Nonetheless many opportunities remain for important future research. The need for such investigations is considerable for gaining a better understanding of the outcomes of health care, given levels of health literacy, and for expanding the knowledge base about the impact of interventions intended to improve health literacy.

Our recommendations for future research into the impact of health literacy or numeracy levels on utilization or health outcomes focus on the following topics: relevant cutpoints for distinguishing levels of health literacy; skill-based health literacy measurement tools that go beyond health-related literacy and numeracy to capture additional and potentially critical skills; mediators and moderators of the effect of lower health literacy on outcomes including knowledge, self-efficacy, beliefs, social support, cultural competency, decisionmaking skills, and trust in the information source; and the potential differential effects of health literacy in various population subgroups defined by sociodemographic characteristics. Methods improvements and better statistical techniques are needed to enable investigators to realize sufficient power to detect differences among the three main health literacy levels, controlling for relevant confounders, and to improve the applicability of results to broader sets of populations and settings.

Future research into interventions to mitigate the effects of low health literacy should be done to test novel approaches to increase motivation, improved techniques for delivering written, oral or numerical information, and “work around” interventions such as patient advocates.

Additional work is also needed to determine the effective components of already tested interventions with combinations of features meant to mitigate the effects of low health literacy. One approach is to conduct qualitative content analyses of existing interventions. Another is to conduct meta-regressions of the results of existing studies to determine the relative impact of different features on relevant outcomes. Finally, additional trials could be run to test components of effective interventions.

Evidence Report

Chapter 1. Introduction

In 2004, the RTI-University of North Carolina Evidence-based Practice Center (RTI-UNC EPC) published a systematic review on literacy and health outcomes supported by the Agency for Healthcare Research and Quality (AHRQ).[1] It concluded (p. vi):

> Low literacy is associated with several adverse health outcomes, including low health knowledge, increased incidence of chronic illness, poorer intermediate disease markers, and less than optimal use of preventive health services. Interventions to mitigate the effects of low literacy have been studied, and some have shown promise for improving patient health and receipt of health care services. Future research, using more rigorous methods, is required to better define these relationships and to guide development of new interventions.

Given a rapidly growing body of literature on literacy and health outcomes, AHRQ commissioned an update to the 2004 review. The current report describes that update and focuses on health literacy as contrasted with literacy *per se*. While the first report was limited to the print literacy component of health literacy, we now consider numeracy and oral literacy as crucial components of health literacy.

Health Literacy

Definition

Health literacy, as defined by Ratzan and Parker[2] and adopted by *Healthy People 2010,*[2,3] and the Institute of Medicine in their 2004 report *Health Literacy: A Prescription to End Confusion*[4] is "the degree to which individuals can obtain, process, and understand the basic health information and services they need to make appropriate health decisions." The concept of health literacy represents a constellation of skills necessary to function effectively in the health care environment and act appropriately on health care information. These skills include print literacy (the ability to interpret documents, and read and write prose), numeracy (the ability to use quantitative information, and oral literacy (the ability to speak and listen effectively).[5] Some authors include in this definition a working knowledge of disease processes, an ability to use technology, an ability to network and interact with others socially, motivation for political action regarding health issues, and self-efficacy.[6,7]

Numeracy is an important component of health literacy and represents "the ability to understand and use numbers in daily life."[8, p. 585] Some individuals may have adequate print and oral literacy but lack the numeracy skills needed to interact successfully with the health care system.[9] These individuals cannot reliably carry out health-related tasks that rely on numeric information, such as interpreting food labels, measuring blood sugar, comparing risk information, or following dosing instructions for medications.[8]

Burden of Low Literacy and Low Health Literacy

In 2003, the US Department of Education conducted a survey entitled "National Assessment of Adult Literacy" (NAAL). The most comprehensive examination of adult literacy to date, the NAAL surveyed more than 19,000 adults ages 16 years and older and included items intended to

measure health literacy directly. More than one-third of respondents (36 percent) taking the NAAL scored in the lowest two ("basic" and "below basic") out of four categories on health literacy items, suggesting that approximately 80 million adults in the United States have limited health literacy, including related prose, document, and quantitative skills.[10] These adults may have difficulty with even simple tasks such as reading and understanding the instructions on a prescription bottle or filling out an insurance form. Although the NAAL did not independently report on prose, document, or quantitative health literacy, its predecessor, the National Adult Literacy Survey (NALS), reported similar proportions of individuals scoring in the lowest proficiency levels across these domains.[9,11] More recent (although not nationally representative) data suggest that many adults may have higher prose literacy than quantitative literacy.[12]

Although a significant proportion of the general population has low health literacy, certain groups have an even higher prevalence of the problem. Such groups include the elderly, minorities, individuals who have not completed high school, adults who spoke a language other than English before starting school, and people living in poverty.[10] For instance, the NAAL demonstrated a higher prevalence of poor health literacy among the elderly. Compared with the 36 percent of all adults who scored in the bottom two categories on the NAAL survey, 59 percent of adults age 65 and older scored in the "below basic" and "basic" range.[10] The association between age and health literacy has proven consistent in other studies of literacy in health care settings. However, the majority of these studies are cross-sectional, making it difficult to determine whether the increased prevalence of poor health literacy in the elderly population results from a cohort effect (e.g., fewer educational opportunities; higher prevalence of a native language other than English) or whether literacy declines with age and/or cognitive function.[13] Both factors likely play a contributing role.

The NAAL also reported a strong relationship between health literacy and race or ethnicity. White respondents scored better on the survey than any of the other racial or ethnic groups evaluated. Although 9 percent of white respondents scored in the lowest ("below basic") category on the NAAL survey, 24 percent of black, 41 percent of Hispanic, 13 percent of Asian, and 25 percent of American Indian and Native Alaskan respondents scored in the "below basic" range.[10] Differences in the quality of education received by disadvantaged members of nonwhite populations may, at least partially, explain this finding. Further, issues of language and acculturation likely play a significant role. The association between health literacy and race and ethnicity raises the question of whether literacy serves as a mediator of racial and ethnic disparities in health. If literacy is related to health outcomes, disparate health literacy levels among different groups could contribute to differential health outcomes.

In addition to age, race, and ethnicity, educational attainment plays a predictably strong role in health literacy. In the NAAL study, more than three-quarters (76 percent) of respondents who had not completed high school scored in the "below basic" or "basic" range of health literacy, compared with only 13 percent of individuals with four-year college degrees.[10] Although one's literacy level is related to one's educational status, the correlation between years of education and literacy is imperfect. Reading grade levels are often several grades lower than the last year of school that people have completed.[14] In addition to the ability to read, the ability to complete 12 years of education may draw on several factors, including social support, community resources, motivation, and family expectations.

Measuring Health Literacy and Numeracy

To date, instruments for measuring health literacy skill levels have focused primarily on the ability to read and, in some cases, to use numbers. A wide range of measures focusing on health literacy and numeracy are now available and applied in the health setting (Table 1 and Table 2, respectively). Currently, no instruments are widely available to measure oral literacy or a set of skills that have been conceptualized as components of health literacy.

As we noted in our original report (and discuss further below), many of the measures used to measure health literacy are highly correlated with general measures of literacy applied in the healthcare setting, suggesting that health literacy and literacy measures provide similar information. Thus, in this review as in our original report, we include studies that purport to measure both health literacy and general literacy in a health setting. We refer to these measures in aggregate as measures of health literacy.

Table 1. Measures of health literacy

Instrument	Description of Test	Method of Assessment	Type of Score	Health Focus	Validation
Literacy Assessment for Diabetes (LAD)[15]	60-item word recognition test for diabetes Length ≤ 3 minutes.	Word recognition	1. Continuous score 2. Grade level (4th-16th)	Yes	Yes
National Adult Literacy Survey (NALS)[9]	~200 questions measuring literacy (prose, quantitative, and document literacy); delivered by item response theory. Includes questions on health literacy.	Reading passages, documents, word problems	1. Continuous score (0-500) 2. Grouped in to five levels (1-5, 5 best): Level 1: <224 Level 2: 225-274 Level 3: 275-324 Level 4: 326-374 Level 5: 375+	No, however, health questions embedded in survey	Yes
National Assessment of Adult Literacy (NAAL)[10]	~200 questions measuring functional health literacy (prose, quantitative, and document literacy), delivered by item response theory. Includes 28 questions on health literacy	Reading passages, documents, word problems	1. Continuous score (0-500) 2. Grouped into four categories: below basic, basic, intermediate and proficient literacy level	No, however, health questions embedded in survey	Yes
Rapid Estimate of Adult Literacy in Dentistry-30 (REALD-30)[16]	30-item test of oral health literacy.	Word Recognition and pronunciation	Continuous score (range 0-30)	Yes	Partial Validation
Rapid Estimate of Adult Literacy in Medicine (REALM)[17]	66-item measure of health literacy. Length about 1 to 2 minutes.	Word recognition and pronunciation	1. Continuous score (0-66) 2. Grade level 0-18: ≤3rd grade 19-44: 4-6th grade 45-60: 7th-8th grade 61-66: ≥9th grade	Yes	Yes

Table 1. Measures of health literacy (continued)

Instrument	Description of Test	Method of Assessment	Type of Score	Health Focus	Validation
Test of Functional Health Literacy in Adults (TOFHLA)[18]	67-item measure of health literacy, including reading comprehension and quantitative skills. Length about 20 to 25 minutes. Available in Spanish and English. Also available in a short form (S-TOFHLA) and British version (UK-TOFHLA); length about 5 to 10 minutes	Reading comprehension (Cloze method) and quantitative skills test	1. Continuous weighted score (0-100) 2. Categorical score 0-59: inadequate 60-74: marginal 75-100: adequate	Yes	Yes
Wide Range Achievement Test, Reading subtest (WRAT)[19]	57 - item measure of literacy from educational literature. Length about 10 minutes.	Word recognition and pronunciation	1. Continuous score (0-57)	No	Yes
Woodcock Johnson, Passage Comprehension SubTest[20]	Test of literacy from educational literature Length 60-70 minutes.	Reading comprehension (cloze method)	Continuous score (range 0-43)	No	Yes

Table 2. Measures of numeracy

Instrument	Description of Test	Method of Assessment	Type of Score	Health Focus	Validation
Diabetes Numeracy Test (DNT)[21]	43-item scale assessing essential numeracy skills for diabetes self-management. Topic areas include: nutrition, exercise, blood glucose monitoring, oral medications, insulin. 30 minutes to administer	Addition, subtraction, multiplication, division, fractions and decimals, multi-step mathematics, time, numeration, counting Includes word problems; interpretation of tables, graphs, or figures; and selection of necessary math functions to solve diabetes-specific problems.	Percentage of correct responses	Yes	Yes Performance on the DNT correlates with diabetes knowledge, self-efficacy, behaviors, and glycemic control.
LIpkus numeracy test[22]	8 or 11 questions assessing numeracy	Converting percentages to proportions, proportions to percentages, and using probability	Percentage correct responses	No	Yes
Schwartz and Woloshin Numeracy Test[23]	3 word problems assessing numeracy	1. Probability 2. Converting a percentage to a proportion 3. Converting a proportion to a percentage	Percentage correct responses	No	Yes
Test of Functional Health Literacy in Adults (TOFHLA), numeracy[18]	17-item scale assessing ability to apply numbers in health context	Assessed the ability to employ numbers in health setting through interpretation of pill bottles, appointment slips, etc.	1. Continuous score (weighted 0-50)	Yes	Yes
Wide Range Achievement Test WRAT-3, arithmetic subtest[24]	55- item scale assessing numeracy skill. Length about 15 minutes.	Counting, Reading number symbols, Solving simple arithmetic problems Standard scores and percentiles compare individual performance with that of others of the same age.	1. Continuous score (0-55)	No	Yes

The instruments most commonly used to measure health literacy in the health literature are the Wide Range Achievement Test (WRAT) reading subtest,[19] the Rapid Estimate of Adult Literacy in Medicine (REALM),[17] and the Test of Functional Health Literacy in Adults (TOFHLA).[18] The WRAT and REALM are word recognition tests that assess whether a person can correctly pronounce a series of words listed in order of increasing difficulty. Both instruments have been validated as instruments of reading ability; they are highly correlated with

one another and other traditional reading assessments in the educational literature.[17] The main difference between the REALM and WRAT is that the REALM uses words commonly encountered in the health care setting. Although this provides the instrument with face validity for use in health care settings, the reported correlation between REALM and WRAT (r = 0.88) suggests that the information provided by the two instruments is similar.[17]

The TOFHLA employs a different approach. It assesses prose literacy using a modified Cloze procedure. In this method, subjects read passages in which every fifth to seventh word has been deleted and then fill in the blanks by selecting the correct word from four choices.[18] The TOFHLA also measures a person's ability to use basic quantitative information (numeracy) by asking a subject to respond to health-related prompts, such as pill bottle instructions and appointment slips. The dual nature of this instrument, therefore, facilitates assessment of both reading comprehension and numerical comprehension (rather than just word recognition).

While developing and validating the TOFHLA, the authors found that the quantitative or "numeracy" subtest was highly correlated with the reading comprehension subtest (r = 0.79). The TOFHLA is also highly correlated with the REALM (r = 0.84) and the WRAT (r = 0.74).[18] A short version (S-TOFHLA)[25] is also available and widely cited in the literature. Although the TOFHLA is labeled as an instrument to measure health literacy, its style and structure, together with validation data, suggest that it is primarily a measure of reading ability similar to the REALM and WRAT.

The most common measures used to measure numeracy in the health literature are the Schwartz and Woloshin Numeracy Measure and the WRAT math subtest. The Schwartz and Woloshin Numeracy Measure consists of 3-items that assess individuals' understanding of probability and their ability to convert between percentages and proportions.[23] The WRAT math subtest assesses individuals' ability to count, read numerical symbols, and perform simple arithmetic operations.[24] A growing number of newer tools (e.g., Diabetes Numeracy Test, Newest Vital Sign) measure numerical skills in the health context, but have not been widely employed to assess the relationship between numeracy and health outcomes.

No gold-standard instrument is currently available to assess adequately the more global concept of health literacy, including the interactions of reading ability, numeracy, and oral literacy. However, as recommended by policymakers, work has begun to define and measure a wider set of skills that might more adequately reflect health literacy.

Relationship between Health Literacy and Outcomes

In the past 15 years, researchers have demonstrated that low literacy can have far-reaching consequences for an individual's health. In our 2004 systematic review and related articles,[26,27] we identified 44 articles describing results that addressed the relationship between literacy and use of health care services, health outcomes, costs of health care, and disparities. The report found that, low or inadequate literacy (compared to adequate literacy) was strongly associated with poorer knowledge or comprehension of health care services and health outcomes.[26,27] Limited literacy was also associated with higher probabilities of hospitalization, poorer global measures of health, a higher prevalence and severity for some chronic diseases, lower utilization of screening and preventive services, and higher probability of hospitalization.[26,27] In many cases, however, the evidence was mixed; both outcomes assessed and analytic methods differed across studies.[26,27] Although literacy was often related to health outcomes in bivariate associations, the relationship sometimes weakened and became statistically non-significant after the investigators adjusted results for covariates such as age, education, socioeconomic status,

health care access, or experience in the health care setting, calling into question whether literacy was truly an independent symptom or merely a marker of other social problems. Outcome differences were rare between a middle literacy group (marginal) and the adequate group. No studies were reviewed that examined differences in costs or differences between race or ethnicity groups.

Based on these findings, the 2004 review recommended that future research: examine more closely and rigorously the factors that mediate the relationship between literacy and health outcomes, and consider other factors that may affect health outcomes such as self-efficacy, self-care, trust and satisfaction; consider prospective cohort studies to examine the relationship between literacy, age, and health outcomes and whether changes in health status affect health literacy levels; stratify outcomes by numeracy level to gain a greater understanding of how these skills may uniquely affect health outcomes and under what conditions numeracy would be a useful indicator for targeting individuals for interventions; and examine the effect of health literacy on costs and on racial, ethnic, and age-related disparities.

Effects of Interventions to Reduce Burden of Low Health Literacy

In our prior review,[26,28] we also identified 29 articles describing interventions to mitigate the effects of low literacy on health outcomes. Of the 29 articles, 20 measured literacy in individual participants and were performed in developed countries. These 20 studies tested a wide range of interventions for improving health outcomes in patients with poor literacy. Most of the interventions occurred in a single session and attempted to make health information more readily available to patients with limited literacy. Some studies compared standard handouts with materials that were written in a simpler, easier-to-read prose. Others compared standard materials with pictographs, booklets, videotapes, or CD-ROMs specially designed for low-literacy audiences. A few interventions used multiple methods.

In aggregate, these studies suggested that interventions may reduce the adverse health effects associated with low literacy.[26,28] However, few studies examined each type of intervention; few examined interventions' effects in literacy subgroups; a minority examined outcomes other than knowledge; and many had methodological flaws limiting conclusions. Based on these observations, we recommended that additional studies of interventions be pursued and that those investigations measure the interventions' effects by literacy subgroup and in a broader range of outcomes.

Need for Update of the Earlier Review

Given the ongoing concern about an association between health literacy level and poor health outcomes, and given the potential to reduce these outcomes with novel interventions, several national organizations have promoted health literacy as a research priority. With such attention from the IOM,[29] the American Medical Association (AMA),[5] the National Institutes of Health (NIH), and the Department of Health and Human Services (Healthy People 2010),[3] the research community in this field has responded with considerable new work since 2004.

To synthesize the increasing volume of literature on health literacy, AHRQ commissioned the RTI–UNC EPC to update its 2004 systematic review examining the effects of health literacy on health outcomes and interventions to improve those outcomes. In this updated report, we focus on the same key questions as the original report, but we also expand our conception of literacy to health literacy and consider separately and in combination, health related literacy

skills, numeracy, and oral health literacy skills. In the results chapters of this report (Chapters 3 and 4), we include only studies that have been published since our last review; we did not systematically re-abstract studies from our earlier review or reassess their quality. We did, however, re-organize data about intervention studies from our first review to highlight features of the interventions and allow interpretation of these features in light of current evidence. Additionally, we compared all findings from the current review to findings from our 2004 review to allow for comprehensive conclusions.

Further, following our review of information available through publications and our review of the quality of the studies based on that information, we queried intervention authors from both the first review and this updated review about key features of the interventions that they had not reported in published articles. This additional information is included in Appendix A.*

Production of This Report

Organization

Health literacy is of particular concern to the AMA, which had originally nominated the topic in 2004, and whose continued interest in the topic is expressed through their representation on the Technical Expert Panel (TEP) for the update review. The report was updated to incorporate an expanding literature and an ongoing interest in the topic area. Our new systematic review consolidates and analyzes the body of literature that has been produced to date regarding the relationship between health literacy and health outcomes and the evidence about interventions intended to improve the health of people with low health literacy.

Chapter 2 describes our methodological approach, including the development of key questions and their analytic framework, our search strategies, and inclusion/exclusion criteria. In Chapter 3, we present the results of our literature search and synthesis of Key Question 1 concerning the relationship between health literacy levels and health outcomes and evaluates the strength of the evidence concerning these outcomes. In Chapter 4, we present the results of our literature search and synthesis of Key Question 2 concerning interventions to assist populations with low health literacy and the strength of the evidence concerning these interventions. Chapter 5 further discusses the findings and offers our recommendations for future research. This is followed by references. Appendices are provided electronically at http://www.ahrq.gov/clinic/epcindex.htm and provide a detailed description of our search strings (Appendix B), our Full Text Inclusion/Exclusion Form and our quality review form used for evaluating the internal validity (including risk of bias) of included studies (Appendix C), detailed evidence tables (Appendix D), Strength of Evidence (SOE) tables (Appendix E), Technical Expert Panel (TEP) members (Appendix F), poor quality studies (Appendix G), and excluded studies (Appendix H).

Technical Expert Panel

We identified technical experts in the field of health literacy to provide assistance throughout the project. The Technical Expert Panel (TEP) (see Appendix F) was expected to contribute to AHRQ's broader goals of (1) creating and maintaining science partnerships as well as public-private partnerships and (2) meeting the needs of an array of potential customers and users of its

products. Thus, the TEP was both an additional resource and a sounding board during the project. The TEP included 8 members: 5 technical/clinical experts; 1 member whose expertise and mission concerns the interests and perspectives of patients and consumers; 2 potential users of the final evidence report; and an AHRQ health literacy expert.

To ensure robust, scientifically relevant work, the TEP was called on to provide reactions to work in progress and advice on substantive issues or possibly overlooked areas of research. TEP members participated in conference calls and discussions through e-mail to refine the scope of this update (including inclusion/exclusion criteria) and discuss our preliminary assessment of the literature. Because of their extensive knowledge of the literature on health literacy, including numerous articles authored by TEP members themselves, and their active involvement in professional societies and as practitioners in the field, we also asked TEP members to participate in the external peer review of the draft report.

Use of This Updated Systematic Review

This updated report addresses the key questions outlined in Chapter 2 through systematic review of published literature. We anticipate that the report will be of value to the AMA for its various efforts to inform and educate physicians. This report can also inform practitioners about the current state of evidence and provide an assessment of the quality of studies that aim to improve health for people with low health literacy. Researchers can obtain a concise analysis of the current state of knowledge in this field and will be poised to pursue further investigations that are needed to improve health for low-health literacy populations. Health educators can also use this report to guide future interventions to improve health communication. Finally, policymakers can use this report to inform new strategies and the allocation of resources toward future research and initiatives that are likely to be successful.

Chapter 2. Methods

In this chapter, we document the procedures used by the RTI International-University of North Carolina Evidence-based Practice Center (RTI-UNC EPC) to develop this comprehensive evidence report *Health Literacy Interventions and Outcomes*, an update to our 2004 systematic review *Literacy and Health Outcomes*. The Key Questions for the update review are the same as those in the original review, with the exception that *literacy* was replaced by the broader term *health literacy*, which acknowledges numeracy and oral literacy in addition to print literacy. In this review as in our original report, we include studies of print literacy that purport to measure both health literacy and general literacy in a health setting. We, however, refer to these measures in aggregate as measures of health literacy. The original review was commissioned by the American Medical Association.

In this update, we reviewed the relevant literature published since our first report in relation to whether health outcomes or interventions are related to literacy or health literacy level. One notable difference between our first report and the current update is that the update does not examine the relationship between health literacy level and knowledge. Our original report found compelling evidence of an association between literacy level and knowledge; thus, we believe this question has already been answered in relation to health literacy. We did, however, continue to include knowledge as a valid health outcome in relation to an individual's numeracy or oral health literacy ability, and for our second key question, which examined whether interventions for low health literacy populations improve health outcomes. Our specific methodology, in conducting an updated review, is discussed below.

To provide a framework for the review, we first present the key questions and their underlying analytic framework. We then describe our inclusion and exclusion criteria, search and retrieval process, and methods of abstracting relevant information from the eligible articles to generate evidence tables. We also discuss our criteria for rating the quality of individual studies and for grading the strength of evidence as a whole.

Key Questions and Analytic Framework

Based on the growing appreciation of the complexity of the relationship between health literacy and obtaining medical care and achieving good health outcomes, we pose two key questions in this report. Both have four parts,

Key Question 1: Are health literacy skills related to

(a) Use of health care services?
(b) Health outcomes?
(c) Costs of health care?
(d) Disparities in health outcomes or health care service use according to race, ethnicity, culture or age?

Key Question 2: For individuals with low health literacy skills, what are effective interventions to

(a) Improve use of health care services?
(b) Improve health outcomes?
(c) Affect the costs of health care?

(d) Improve health outcomes and/or health care service use among different racial, ethnic, cultural, or age groups?

Figure 1 depicts the analytic framework for our key questions. Solid lines show the relationship between health literacy skills and outcomes (KQ 1) and between interventions and outcomes (KQ2); dotted lines show factors that might influence (i.e. moderate or confound) these relationships.

Figure 1. Analytic framework for the health literacy systematic review

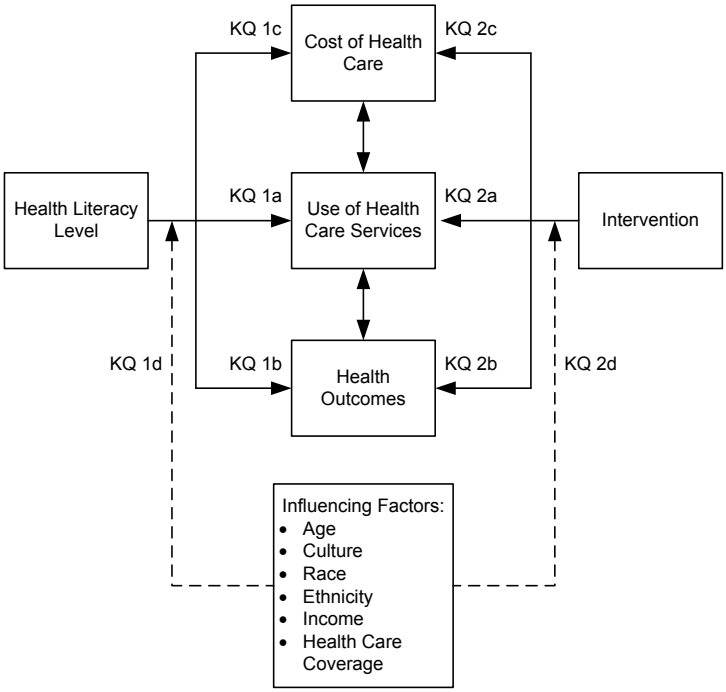
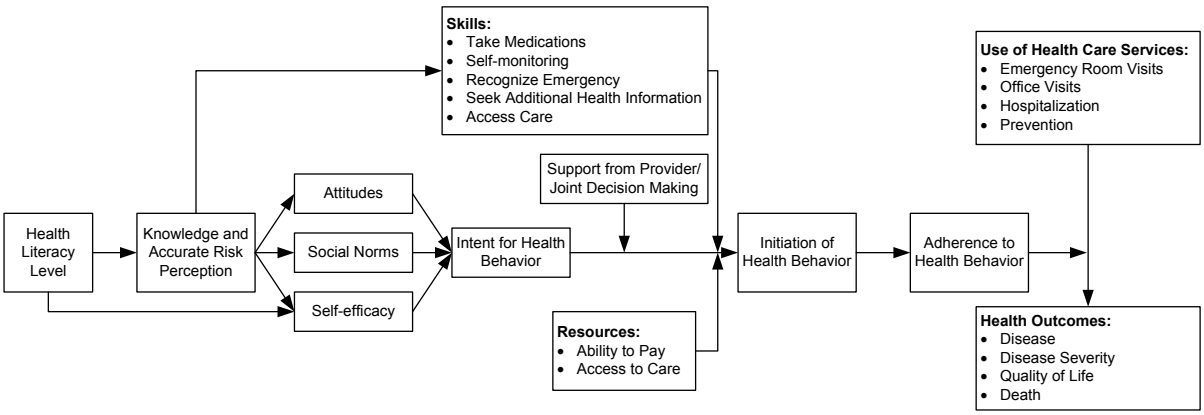


Figure 2 outlines a more detailed logic model explicating outcomes that were included in our review and their conceptual relationship to each other. This model draws both on an integrated model of behavioral theory[30] and on several proposed models of health literacy proposed by researchers in the field.[30,31] This more detailed model was used to determine whether studies considered for inclusion have relevant health outcomes. It also guides our analysis of included articles.

Figure 2. Logic model for the health literacy systematic review



For KQ 1a and 2a, we consider any process of care as a health service; this includes clinic and hospital visits, hospitalizations, and use of preventive and screening services. For KQ 1b and 2b, we use the term "health outcomes" broadly to encompass both intermediate and distal outcomes, even though in many cases the intermediate outcomes will be only surrogates or proxies for health-related end results of care. Outcome categories include the following:

- *Knowledge:* As described above, we consider knowledge as a final outcome only in relation to numeracy (KQ 1) and intervention studies (KQ 2). We do not include it in our consideration of the relationship of literacy and health outcomes (KQ 1) because evidence in the earlier review clearly concluded that greater literacy skills and higher health-related knowledge levels are positively related.
- *Self-efficacy:* Self-efficacy, a person's confidence in his or her ability to carry out a health behavior, is an important intermediate outcome in many behavioral theoretical models. It is a predictor of behavioral intent.
- *Behavioral Intent:* Behavioral intent is a person's stated likelihood of starting a behavior. It is an important hypothesized intermediate step in the causal pathway between health literacy level and health outcomes.
- *Skills and Behaviors:* The relationship between health literacy and intermediate and ultimate outcomes depends on a person's health skills and behaviors. Skills include a person's *ability to* recognize emergency situations, seek additional health information, or access needed health care. Behaviors include *actions* such as taking medication, changing one's lifestyle, or monitoring one's health.
- *Adherence to health behavior:* Adherence is the ability to carry out a health behavior over a meaningful period of time, such as regularly taking a medication "as prescribed" over the period of time for which it is prescribed. Adherence is an important predictor of health outcomes.
- *Measures of disease incidence, prevalence, morbidity, and mortality:* This category includes such outcomes as rates of physical and mental health conditions, stages of cancer presentation, severity of diseases, measures of disease control and complications, and death rates. These outcomes may be measured by biomarkers, validated survey instruments and questionnaires, patient self-report, or, in the case of mortality, vital records or proxy reports.
- *Health status:* This outcome includes generic (and condition-specific) measures of health status or health-related quality of life; the domains of interest are physical health and mental health functioning (e.g., cognitive abilities), pain or fatigue, and perhaps social functioning and social networks. They are usually assessed by self-report questionnaires that have been shown to predict health outcomes.

Of particular note for KQ 1a is that we did not examine outcomes related to attitudes or perceived social norms (although we show them in our model). This decision was based on the belief that attitudes and perceived social norms result from knowledge which, as described above, is not examined in the current report. Further, we did not examine outcomes related to patient-provider relationships (e.g., shared or informed decision making) because we thought that such relationships or decisions likely moderated (rather than mediated) the effect of behavioral intent on health outcomes. This distinction between mediating and moderating is important. A moderator affects the direction or strength of a relationship between an independent and

dependent variable; a mediator, on the other hand, *accounts* for that relationship, answering the question as to how or why things occur.

For KQ 1c on measuring the cost of health care, we included any study that measured the monetary cost of health care services including both direct and indirect costs. For KQ 2c, we also included studies measuring the cost of the intervention.

Finally, to address KQs 1d and 2d, concerning disparities in health outcomes and use of health care services, we looked for studies that reported on health literacy level as a *mediator* of the relationship between age, race, ethnicity, or cultural background, and health outcomes (or the effectiveness of interventions) and also included studies that reported *moderators* of the strength of the relationship between health literacy and health outcomes.

Literature Search and Retrieval Process

Databases Search Terms. To identify the relevant literature for our review, we searched five electronic databases: MEDLINE®, the Cumulative Index to Nursing and Allied Health (CINAHL), the Cochrane Library, PsychINFO, and the Educational Resources Information Center (ERIC). For health literacy, we searched using a variety of terms, limited to English and human-only studies published from 2003 to March 2009. For numeracy, we searched from 1966 to March 2009. We conducted key word searches because no MeSH headings specifically identify health literacy-related articles. The terms "health literacy," "numeracy," and "literacy," and terms or phrases related to instruments known to measure health literacy and numeracy were the focus of the search. We limited the "health literacy" and "literacy [tw]" searches to 2003 forward (including up to one year overlap with our earlier review) to be confident that we did not miss studies between the first review and this update and to ensure that we did not unnecessarily overlap with the literature reviewed earlier. Editorials, letters to the editor, and case reports were excluded.

Across all databases searched, our initial searches yielded 2,855 citations (Appendix B). We reviewed our search strategy with the Technical Expert Panel (TEP) and further supplemented our electronic searches by hand searching the reference lists of included studies and of 57 pertinent excluded articles.

We imported all citations into an electronic database (EndNote X.3) for a final unduplicated yield of 2,890 articles. We plan to conduct an updated literature search before completing the final version of the report.

Study Selection Process

Inclusion and Exclusion Criteria

For each KQ, we developed detailed eligibility criteria with respect to population, intervention, comparison, outcomes, time frames, and settings (the PICOTS framework). The final criteria include the following:

KQ 1: Relationship of health literacy levels to utilization, outcomes, costs, and disparities

- **Population:** Individuals and caregivers of all races and ethnicities.
- **Intervention:** Not applicable.
- **Comparison:** Different levels of health literacy or numeracy skills.
- **Outcomes:** For studies of outcomes by levels of health literacy, relevant health or cost outcomes with the exception of knowledge; the relationship between literacy and health-related knowledge was considered well-established through the earlier review. For studies of outcomes by numeracy levels, relevant health or cost outcomes *and* knowledge.
- **Time:** Cross-sectional or longitudinal studies, with varying lengths of time for follow-up, and with no restrictions for when the studies or data collection activities were done.
- **Setting:** No exclusions by setting, so includes inpatient or outpatient settings in health care systems and institutions, various community-based settings, or homes.

KQ 2: Effective interventions to improve utilization or health outcomes or to affect costs, including by population subgroups

- **Population:** Individuals and caregivers of all races and ethnicities with low health literacy.
- **Intervention:** All interventions intended to improve the use of health care services or health outcomes in low health literacy or numeracy individuals; this includes, but is not limited to, interventions addressing knowledge, patient/provider communication and barriers to health care, self-efficacy, or behavior change.
- **Comparison:** Any comparator designated by the investigators. A comparator is not necessary for studies with pre-post intervention measures.
- **Outcomes:** Any health related health care utilization, health outcomes, or cost.
- **Time:** Studies (controlled and uncontrolled trials, and observational studies) with varying lengths of time for follow-up and with no restrictions for when the studies or data collection activities were done.
- **Setting:** No exclusions by settings.

Based on the final key questions specified above, we generated a list of inclusion and exclusion criteria (Table 3). We included prospective and cross-sectional observational studies of health outcomes, trials of materials developed for low-health literacy populations, and trials of interventions that compared materials designed to be "easier to read or understand" with standard materials. We limited studies to those with outcomes related to health and use and costs of health services. Because this is an update to our original report, we limited our searches to studies that would not have been considered during the earlier review (e.g., those more recently published, those for which numeracy or oral health literacy were the exposure).

As described in Table 3, we excluded studies for several reasons, including lack of any outcome of interest or results limited to the readability of materials. We also excluded studies that focused on literacy or health literacy as an outcome rather than an exposure, as is seen, for instance, in studies of physician office-based programs designed to improve children's literacy or

studies of socio-demographic characteristics more likely to be associated with differences in health literacy level. We also excluded studies that used cognitive impairment or dementia as an outcome of interest because we would not be able to determine whether health literacy levels were causing or being affected by the condition.

Table 3. Inclusion/exclusion criteria for studies considered in this update

Category	Criteria
Study population	All races, ethnicities, and cultural groups. Patients of all ages and caregivers whose primary language is the same as that of the health care provider and/or intervention. Health literacy or numeracy levels of the population must be reported.
Time period	Published from 2003 to March 2009: Print literacy or health literacy studies meeting other inclusion criteria and newly published since our earlier review. Published from 1980 to March 2009: Numeracy and oral health studies excluded from the earlier review and meeting other inclusion criteria.
Publication criteria	English only. Articles in print. Excluded were articles accepted for publication but not in print in the journal, articles in the so-called "grey literature," and articles we could not obtain during the review period.
Admissible evidence (study design and other criteria)	Original research studies that provided sufficient detail regarding methods and results to enable use and adjustment of the data and results. Eligible study designs included • before-and-after studies; • controlled trials; and • observational studies: prospective and retrospective cohort studies, case control studies; and cross-sectional studies. Relevant outcomes must be able to be abstracted from data presented in the papers. Sample sizes must be appropriate for the study question addressed in the paper; single case reports or small case series (fewer than 10 subjects) were excluded. Other study exclusion criteria included studies • of dyslexia and dementia • of normal reading development in children • with no health outcomes or no use of health care services • with an outcome limited to satisfaction or likeability of one intervention material compared to another, or attitudes, perceived social norms, or patient-physician interaction measures • solely about the readability of materials • in which health literacy, numeracy or oral health literacy are not directly measured in the population and/or linked to outcomes at an individual level • in which the outcome is limited to dementia or cognitive impairment. • in which health literacy is the exposure (KQ 1) and the only study outcome is knowledge • of the basic experimental science of reading ability (e.g., studies of brain function, including results from magnetic resonance imaging or electroencephalogram) or basic educational achievement • solely or chiefly for validation of an instrument • in which the intervention was not designed to address low health literacy.

Changes from the Prior Review

As is appropriate for an update of an earlier review, our overall goal was to evaluate whether newer literature was available and appropriate for answering our key questions. In response to advances in measuring and studying health literacy and in conducting systematic reviews of the literature, we made several changes to the methods of our review.

- We broadened our definition of health literacy to be consistent with the Ratzan and Parker definition used by Healthy People 2010 and the Institute of Medicine.[2] The primary result of this step is that we are now including studies that evaluated the numeracy skills of participants. Our inclusion criteria encompassed studies that used measures of oral (spoken) health literacy or other skills-based approaches to health literacy measurement, but we did not find any such published studies.
- We excluded intervention studies that did not measure health literacy directly in the study sample. In the earlier review, we had included such studies, even though they provided weaker evidence, because of the then-current limitations in the available literature. The body of literature has expanded sufficiently so that this relaxation of rigorous inclusion criteria was no longer necessary.
- The instrument used to measure health literacy had to do so directly. This time we excluded studies that were limited to a measure of an individual's self-report of his or her health literacy, literacy, or numeracy abilities. Therefore, we excluded studies that measured a participant's literacy in response to a question such as, "Can you read"?
- We modified our criteria concerning the evaluation of individual study quality to ensure that we incorporated advances in the methodology of conducting systematic reviews of the literature. Also, in keeping with current practice, we did not determine the overall quality of a study based on a numeric summary of individual criteria.
- We included studies that were conducted in developing countries as long as they had an objective measure of literacy or health literacy measured directly in participants.
- We queried investigators of all intervention studies regarding missing information about their interventions to allow richer interpretation about what interventions may be effective in mitigating the effects of low health literacy.

Process for Considering Abstracts and Full Articles for Inclusion

Once we had identified articles through the electronic database searches, review articles, and reference lists, we examined abstracts of articles to determine whether the studies met our criteria for inclusion. Each abstract was independently, dually reviewed for inclusion or exclusion. If one reviewer concluded that the article should be included in the review, we obtained the full text. If two reviewers independently determined that the abstract did not meet eligibility criteria, we excluded it.

In the full article review, two team members again read each article and decided whether it met our inclusion criteria, using a Full-Text Inclusion/Exclusion Form (Appendix C). Reviewers discussed any disagreements, and if they could not resolve them, the disposition of the article was decided by discussion among the larger team. Excluded articles are listed in Appendix H.

Literature Synthesis

Development of Evidence Tables and Data Abstraction Process

The senior staff members for the systematic review jointly developed the design of the evidence tables. Evidence tables were designed to provide sufficient information to enable readers to understand the study and to determine study quality. In our design, we gave particular emphasis to essential information to answer our key questions and to determine study quality. The format of the tables, which was based on successful designs used for many prior systematic reviews from this EPC (not just the review of health literacy and outcomes), varied slightly by key question; the tables for KQ 2 have additional columns that describe the control group, the intervention group, and specifics of the intervention.

We trained abstractors by having them abstract several articles into evidence tables and then reconvened as a group to discuss the results, including the utility of the table design. The abstractors repeated this process several times until everybody was capable of working with the tables, instructions, and other elements of the process.

Abstractors entered data directly into evidence tables. The first abstractors entered all relevant information into the evidence table. Second reviewers subsequently checked each abstraction for accuracy and completeness against the original articles. Abstractors reconciled all disagreements concerning the information reported in the evidence tables.

Abstractors, at the time of initial data abstraction, also performed a quality review (internal validity or risk of bias) and rating of each study, using a separate quality review form for this process (Appendix C). As with data abstraction, second reviewers independently conducted a quality review and rating of each article. When ratings conflicted, each pair of reviewers for each quality question discussed the problem; issues they could not resolve were brought to a third party for resolution where necessary.

The final evidence tables for KQ 1 (health literacy and numeracy separately) and KQ 2 are presented in their entirety in Appendix D. Entries for all evidence tables are listed alphabetically by the last name of the first author; multiple articles by the same team of authors will be entered alphabetically by second or later authors. A list of abbreviations used in the evidence tables appears at the beginning of the appendix.

Quality Rating of Individual Studies

To assess the quality (internal validity including risk of bias) of studies, we used predefined criteria based on those developed for the earlier review. We adapted criteria from the US Preventive Services Task Force, the National Health Service Centre for Reviews and Dissemination, the Agency for Health Research and Quality's Evidence Based Practice Center Systematic Review Manual, and a report on the quality of observational studies developed by the RTI-UNC EPC.[32] We specifically addressed methodological issues including selection bias, measurement bias, confounding, and power.

Unlike our previous review, we rated the overall quality of studies qualitatively. In general terms, a "good" study has the least bias and results are considered to be valid. A "fair" study is susceptible to some bias but probably not enough to invalidate its results. A "poor" rating indicates significant bias (stemming, e.g., from serious errors in design or analysis) that may

invalidate the study's results. A copy of the form used for quality rating a study is included in Appendix C.

As described above, two independent reviewers assigned quality ratings to each study. Disagreements were resolved by discussion and consensus or by discussion with the larger study team. Studies that met all criteria were rated good quality. Studies received a quality rating of fair when they presumably fulfilled all quality criteria but did not report their methods to an extent that answered all our questions or did not adequately fulfill all quality criteria. Thus, the fair quality category includes studies with quite different strengths and weaknesses. Studies that had a fatal flaw (defined as a methodological shortcoming that leads to a very high probability of bias) in one or more categories were rated poor quality and excluded from our analyses. Poor quality studies and reasons for that rating are presented in Appendix G. In situations where we concluded different quality ratings for different outcomes within the same study, we provide the quality rating for each.

Data Synthesis

We synthesized the data in our review qualitatively. We did not have a sufficient number of studies with similar outcomes or similar interventions to consider quantitative analysis (meta-analysis or statistical pooling) of data. Furthermore, we primarily considered only information from the *current* searches. Given changes in our evidence tables and quality forms, we reviewed individual studies from the 2004 review in depth *only* if new evidence would seem to change overall conclusions. Because the structure of analysis for KQ 2 changed for this current review, we reorganized the 2004 review findings from KQ 2 to be consistent with our current organizational structure for results.

Grading the Strength of Available Evidence

We evaluated the strength of evidence based on the AHRQ *Methods Guide for Comparative Effectiveness Research*.[33] To determine overall strength, we first examined several key features contributing to evidence strength: risk of bias, consistency, directness, precision, and the presence of other modifying factors. We then combined these factors to grade the overall strength of evidence. As described in Owens et al., the evaluation of risk of bias includes assessment of study design and aggregate quality of studies.[33] We judged good quality studies with strong designs to yield evidence with low risk of bias. We graded evidence as consistent when effect sizes across studies were in the same direction and of similar magnitude. When the evidence linked differences in health literacy skill level or interventions directly to health outcomes, we graded the evidence as being direct. We graded evidence as being precise when results were in the same direction and had a narrow range.

Consistent with EPC policy, we independently dually evaluated the overall strength of evidence for each outcome based on a qualitative assessment of strength of evidence for each of the key features listed above. We then reconciled all disagreements through discussion by senior members of the team. The levels of strength of evidence as specified by AHRQ are shown in Table 4.

Table 4. 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.
Insufficient	Evidence either is unavailable or does not permit estimation of an effect.

Applicability of the Evidence

We evaluated the applicability of the evidence based on a qualitative assessment of the population, intensity or quality of treatment, choice of the comparator, outcomes, and timing of follow-up. Specifically, we considered whether enrolled populations differ from target populations, whether studied interventions are comparable with those in routine use, whether comparators reflect best alternatives, whether measured outcomes are known to reflect the most important clinical outcomes, and whether follow-up was sufficient.

Peer Review Process

Among the more important activities involved in producing a credible evidence report is conducting an unbiased and broadly based review of the draft report. External reviewers are clinicians, researchers, representatives of professional societies, and potential users of the report, including TEP members. Peer reviewers are asked to provide comments on the content, structure, and format of the evidence report and to complete a peer review checklist. We will revise the report, as appropriate, based on comments from peer reviewers.

Chapter 3. Results: Relationship of Health Literacy to Outcomes and Disparities

This chapter presents the results of our literature search for Key Question (KQ) 1 and KQ 2. It also reports our findings for KQ 1; we illustrated and discussed this KQ in Chapter 2 and Figures 1 and 2. Specifically, KQ 1 asked whether health literacy skills are related to (a) use of health care services, (b) health outcomes, (c) costs, and (d) disparities in outcomes or utilization according to race, ethnicity, culture, or age.

We report our results in three main sections of this chapter. We deal initially with specific details about the yields of the literature searches and the number of studies meeting our inclusion criteria to answer KQs 1 and 2. We then report on the findings for outcomes studies that pertain to KQ 1, in two ways: first, we address issues when health literacy or literacy (hereafter referred to as health literacy) was measured in the population being studied; second, we examine topics when numeracy was specifically measured. In studies that measured health literacy, we compared the new results broadly with those found during the earlier review (*Literacy and Health Outcomes*[1]). All numeracy studies are discussed in this chapter because none had been included in the earlier review. We did not find any studies meeting our inclusion criteria addressing outcomes or interventions related to oral health literacy.

Table 1 (health literacy) and Table 2 (numeracy) in Chapter 1 presented common instruments used for measuring health literacy and numeracy; many of these instruments are used by studies detailed in this chapter. Studies using measures of health literacy that assess but do not separately report on numeracy are reported with health literacy results. Summary tables presenting selected information on each KQ 1 study will be found at the end of the chapter. Detailed evidence tables appear in Appendix D.

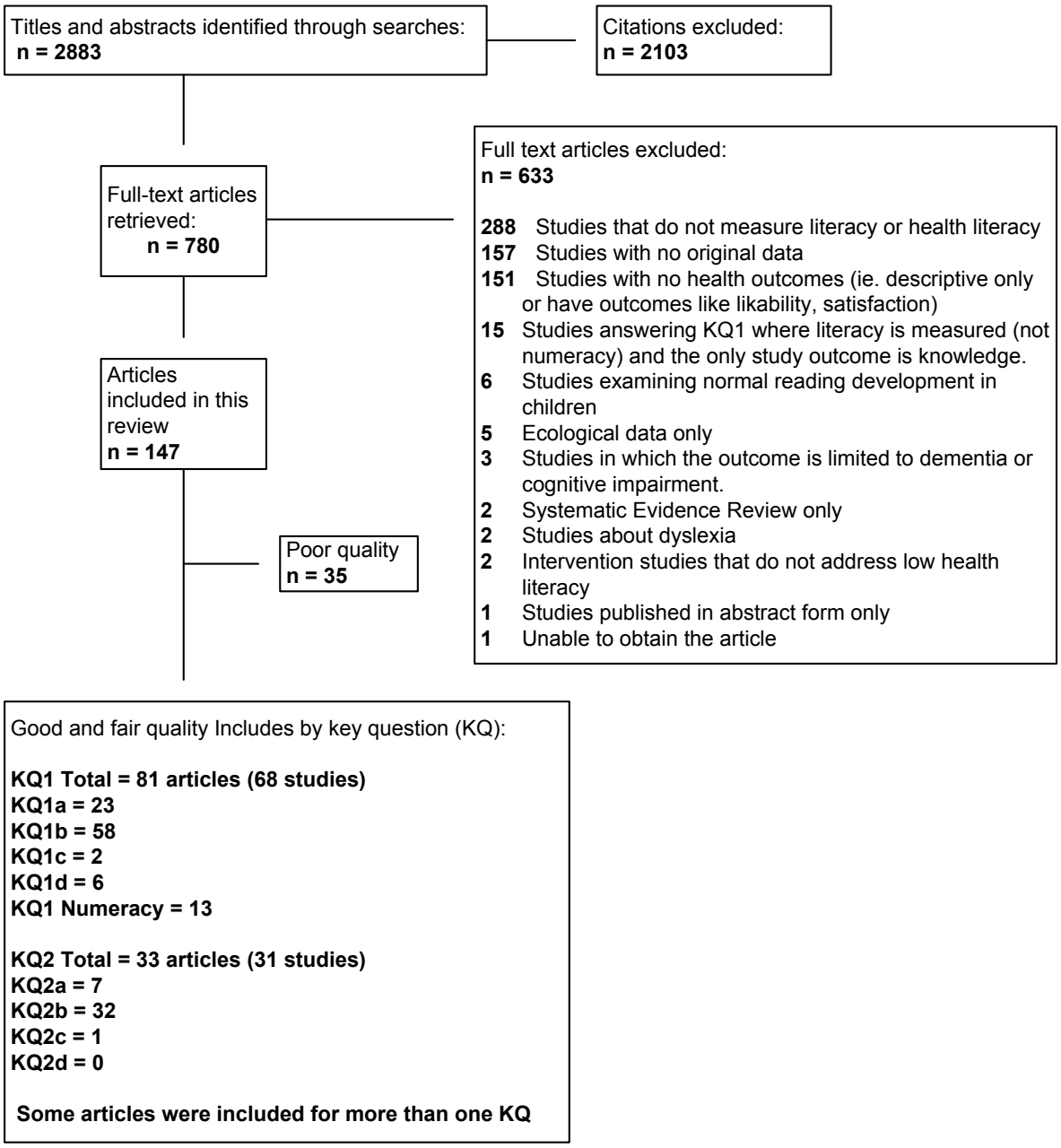
Tables 7 through 10, 12, and 13, called out below, contain the aggregate strength of evidence grades based on the studies included in the update to answer KQ 1. Chapter 2 described the methods for arriving at strength of evidence grades; Appendix E gives the domain-specific scores used in deriving the overall grades. We provide grades for particular outcomes. Where specified, grades are limited to particular populations related to limitations in the availability of evidence. Unless otherwise specified, results are stated in terms of the association with lower literacy. To reiterate, the definitions of the overall strength-of-evidence grades are as follows:

- 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.
- Insufficient: Evidence either is unavailable or does not permit estimation of an effect.

Results of Literature Search

Our literature search yielded 2,883 articles (Figure 3). Of these, we excluded 2,103 articles after reviewing the abstracts and pulled 780 articles for full text review. We also conducted full text reviews of 15 articles identified by hand searching articles and Web-based bibliographies and recommendations from our Technical Expert Panel (TEP).

Figure 3. PRISMA tree: Flow diagram depicting review and disposition of articles



Key Question 1: Relationship of Health Literacy to Various Outcomes and Disparities

We identified 81 good or fair quality articles reporting on 68 unique studies for this topic. These studies report results about the relationship between health literacy and use of health care services, health outcomes, and costs of health care and disparities between specific racial, ethnic, cultural, or age groups. Eleven studies were of good quality and 70 of fair quality, according to the criteria described in Chapter 2. In addition, we identified 26 studies which were considered to be of poor quality and therefore not included in the analysis (Poor quality studies are listed in

Appendix G; we do not discuss them further in this review.) In the text below, we identify only studies of good quality; all others for which quality is not specifically called out are fair quality.

Multiple studies reported results using the same data. For instance, eight articles reported results collected during the "Prudential study." This study was conducted with 2,923 new members in a Prudential Medicare managed care plan of enrollees in Cleveland, Ohio; Houston, Texas; Tampa and South Florida.[34-41] Other studies reported in multiple articles include 3 articles reporting on a sample of patients at Chicago, Illinois and Shreveport, Louisiana HIV clinics[42-44] and 2 articles reporting on patients in 3 primary care clinics in Chicago, Illinois; Shreveport, Louisiana; and Jackson, Mississippi.[45,46]

Studies examined a variety of outcome measures including use of health care services (hospitalization and emergency department, screening and immunizations), access to care, and health outcomes (adherence, self-efficacy, health behaviors, health care related skills, disease prevalence and severity, health status, and mortality) (Table 5). Studies also examined differences in costs and disparities related to health literacy level.

Table 5. Overview of health literacy studies

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Baker et al., 2004[35] Cohort Good	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Any ED visits • 1 ED visit • 2 or more ED visits • Number of physician visits	• Age • Gender • Race • Physical and Mental health • Chronic diseases • Smoking • Alcohol use • BMI • Study site • Months enrolled
Baker et al., 2007[38] Prospective cohort Good	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• All cause mortality • Cardiovascular mortality • Cancer mortality • Non-cardiovascular, non-cancer mortality • Physical HRQoL (SF-12) • Mental HRQoL (SF-12) • IADL limitation • ADL limitation • Number of chronic conditions (unadjusted) • BMI (unadjusted)	Baseline measures: • Number of chronic conditions • Physical health score • Mental health score • IADL limitation • ADL limitation • Smoking • Alcohol use • Vigorous physical activity • BMI

ADL, activities of daily living; ASI-Alc, Addiction Severity Index – Alcohol; ASI-Drug, Addiction Severity Index – Drugs; BMI, body mass index; CD4, cluster of differentiation 4; CHF, congestive heart failure; COPD, Chronic Obstructive Pulmonary Disease; CRC, colorectal cancer; C-SDSCA, Chinese version of the Summary of Diabetes Self-Care Activities measure; DBP, diastolic blood pressure; DRUGS, Drug Regimen Unassisted Grading Scale; ED, emergency department; ER, emergency room; FACT-G, Functional Assessment of Cancer Therapy-General; FOBT, federally qualified health center; FQHC, fecal occult blood test; GA, Georgia; HADS, hospital anxiety and depression scales; HAQ, health assessment questionnaire; HbA1c, glycosylated hemoglobin; HIV, human immunodeficiency virus; HRQoL, health related quality of life; IADL, instrumental activities of daily living; Il, Illinois; INR, International Normalized Ratio; LA, Louisiana; LDL, low density lipoproteins; LVEF, left ventricular ejection fraction; MI, Michigan; NC, North Carolina; NYC, New York City; NYHA, New York Hospital Association; Pap, Papanicolau test; SBP, systolic blood pressure; Serum K, serum potassium; Serum Na, serum sodium; SF, short form; SF, short form; TN, Tennessee; U.S., United States; USA, United States of America; VA, Veteran's Administration; VRQoL, vision related quality of life.

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Baker et al., 2008[47] Prospective cohort Good	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• All cause mortality • Cardiovascular mortality • Cancer mortality • Non-cardiovascular, non-cancer mortality	Baseline measures: • Number of chronic conditions • Physical health score • Mental health score • IADL limitation • ADL limitation • Smoking • Alcohol use • Vigorous physical activity • BMI • Cognitive functioning
Barragan et al., 2005[48] Cross-sectional Fair	372 patients at an inner city public hospital urgent care center, Atlanta, GA	• HIV Test Acceptance	• Age • Education
Bennett et al., 2007[49] Cross-sectional Fair	99 pregnant patients receiving prenatal care in clinics in Philadelphia	• Elevated depressive symptomatology	• Mexican nativity • Recent marijuana use
Bennett et al., 2009[50] Cross-sectional Good	2,668 U.S. adults 65 years and older in a nationally representative sample	• Mammography • Influenza vaccine • Health status	• Age • Race • Gender • Income • Nativity
Chew et al., 2004[51] Prospective cohort Fair	332 patients at a preoperative clinic of the VA Puget Sound	• Non-adherence to fasting instructions • Non-adherence to pre-operative medication instructions	• Age • Marital status • Number of medications • Cognitive functioning
Cho et al., 2008[52] Cross-sectional Fair	489 elderly outpatients at hospital and an FQHC in Chicago	• ER Visits • Hospitalizations • Preventive care • FOBT • Mammography • Health status (self report) • Non-adherence: • Failed to fill prescriptions on time • Health behavior measured through Health Promoting Lifestyle Profile	• Race • Ethnicity • Gender • Educational attainment

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
DeWalt et al., 2007[53] Retrospective cohort Fair	150 patients at a General, Asthma and Allergy, and Pulmonary clinic at children's hospital	• Child ED Visits • Hospitalizations • Albuterol use (unadjusted) • Appropriate comptroller use (unadjusted)	• Child age • Household income • Parental race • Parental asthma knowledge • Parental smoking • Asthma severity classification • Controller medication use • Site of care
Estrada et al., 2004[54] Prospective cohort Fair	143 adults greater than 50 years old on warfarin ≥ 1 month in 2 anticoagulation management units	• Warfarin control measured through INR variability and INR in the therapeutic range	• Age
Fang et al., 2006[55] Cross-sectional Fair	179 patients at anticoagulation clinic in San Francisco, California	• Adherence to medication as measured by self-report of missed doses over 3 time periods (last 3 days, last 2 weeks, > 3 months) • No missed doses > past 3 months	• Age • Sex • Race/ethnicity • Education • Cognitive impairment • Years on warfarin
Garbers et al., 2004[56] Cross-sectional Fair	205 women recruited through their younger female relatives in two women's health centers in New York City	• Ever had a Pap test • Pap test within past 3 years	• Having a source of care • Having any health insurance • Age • Years in the US • Education
Gazmararian et al., 2006[34] Prospective cohort Fair	1,549 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Non-adherence to cardiovascular medication refill adherence (1 year period)	• Age • Race • Gender • Education • Regimen complexity
Graham et al., 2007[57] Retrospective cohort Fair	87 patients at an HIV clinic in Philadelphia, Pennsylvania	• < 95% adherence to HIV medication regimen (self-report of pill counts over past 3 months)	• Mediator: Individual's norm for acceptable adherence

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Grubbs et al., 2009[58] Retrospective cohort Fair	62 patients in 5 San Francisco bay outpatient dialysis units	• Time from dialysis date to transplant list referral date • Time from transplant list referral date to waitlist date	• Race • Gender • Income • Age at start of dialysis • Support • Hypertension • Diabetes • Peripheral vascular disease • Coronary artery disease • HIV • Hepatitis C • Congestive heart failure • Depression • Drug abuse
Guerra et al., 2005[59] Cross-sectional Fair	136 patients at 4 community clinics, 2 university practices in Pennsylvania	• FOBT • Sigmoidoscopy or Colonoscopy	• Ethnicity • Medicaid • Education • Income
Guerra et al., 2005[60] Cross-sectional Fair	97 patients at 3 community health plans in Philadelphia, Pennsylvania	• Mammography	• Age • Education • Acculturation • Insurance Status
Hahn et al., 2007[61] Cross-sectional Good	415 adult cancer patients in 5 Chicago area cancer centers	• FACT-G: Physical well-being, Emotional well-being, and Functional well-being • SF-36: Physical functioning, Role-Physical, Bodily pain, Vitality, Mental health, Fair/poor health • Standard Gamble utility score	• Age • Gender • Race/ethnicity • Work status • Marital status • Living arrangement • Socioeconomic status • Prior computer experience • Cancer diagnosis • Stage at diagnosis • Months since diagnosis • Current chemotherapy treatment • Performance status
Hibbard et al., 2007[62] Cross-sectional Fair	303 community participants	• Choosing a quality choice hospital	• Age • Gender • Education • Comprehension • Activation

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Hironaka et al., 2009[63] Prospective cohort Fair	110 caregivers of infants who receive care at 2 pediatric clinics	• Days of adherence to giving vitamins to their infants in prior week	• Race/ethnicity • Caregiver education • Caregiver concerns regarding multivitamins and possible side effects • Randomized assignment to drops or sprinkle formulation
Hope et al., 2004[64] Cohort Fair	61 control group RCT participants with CHF in Indianapolis, Indiana	• ED visits	• Race • NYHA classification • Medications • Reading score
Howard, et al., 2005[41] Cohort Good	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Use of Inpatient, outpatient, emergency department, or pharmacy services • Costs 1 year period: overall, inpatient, outpatient, pharmacy • Depression (unadjusted) • Heart attack (unadjusted) • Angina (unadjusted) • Stroke (unadjusted) • COPD (unadjusted)	• Age • Sex • Race/Ethnicity • Income • Education • Tobacco • Alcohol • Comorbidities
Howard, 2006[36] Cohort Fair	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Physical HRQoL (SF-12) • Mental HRQoL (SF-12) • IADL limitation • ADL limitation • Physical HRQoL • Mental HRQoL • Self-reported health good or higher • Receipt of influenza vaccine • Receipt of pneumococcal vaccine	• Age • Gender • Race/ethnicity • Education • Income • Site • Morbidity • Smoker
Huizinga et al. 2008[65] Cross-sectional Fair	160 patients at primary care clinic at Vanderbilt University	• BMI (unadjusted)	• None
Johnson et al., 2005[66] Cross-sectional Fair	107 adult patients at spinal cord injury clinic in New Jersey	• Physical morbidity • Mental health morbidity • SF-12 Physical Component score • SF-12 Mental Component score • Physical independence • Mobility	• Motor index • Education

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Kalichman et al., 2008[67] Prospective cohort Fair	145 HIV positive adults in Atlanta, Georgia	• Antiretroviral therapy pill adherence (pill counts averaged over past 4 months) • Depression (unadjusted) • HIV symptoms (unadjusted)	• Age • Education • Years since testing HIV positive • HIV symptoms • Depression • Internalized stigma • Social support • Alcohol use
Kripalani et al., 2006[68] Cross-sectional Good	152 patients with coronary heart disease at clinic in Atlanta, Georgia	DRUGS: Requiring observed completion of 4 tasks: • Identify appropriate medication • Open container • Select correct dose • Report appropriate timing of doses.	• Age • Education • Cognitive functioning
Laramee et al., 2007[69] Cross-sectional Fair	998 adults with diabetes in primary care practices in Vermont, New Hampshire, and northern New York State	• Heart failure	• None
Lee, 2009[70] Cross-sectional Fair	489 seniors who are patients at 1 of 2 Chicago, Illinois clinics	• General health (self report) • Physical health (SF-12) levels • Mental health (SF-12) levels	• Age • Gender • Race • Education • Marital status • Income • Social support level
LeVine et al., 2004[71] Cross-sectional Fair	167 mothers of kindergarten age children in urban and rural Nepal	• Comprehension of radio health messages • Comprehension of visual print health message • Ability to give an organized health related narrative	• Maternal schooling • Childhood socioeconomic status • Age • Current socioeconomic status • Husband's schooling • Urban/rural

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Lincoln et al., 2006[72] Prospective cohort Fair	390 adults in an inner-city short-term inpatient detoxification unit	• Depressive symptomatology • ASI-Alc • ASI-Drug	• Time • Sex • Age • Race • Education • Income • Primary language • Primary substance of choice • Randomization group • Mini-mental status exam • Baseline outcomes variable
Lindau et al., 2006[73] Cohort Fair	68 patients at clinics in Chicago area academic medical center	• Patient followed up on time after abnormal Pap • Patient followed up within one year	• Age • Race • HIV status • Cancer • Unemployment • Insurance
Mancuso et al., 2006[74,75] Cross-sectional Fair	175 patients at a primary care practice in New York City	• Access to asthma care • Access to care due to other conditions • Asthma related quality of life • Physical health related quality of life (SF-36)	• Age • Race/ethnicity • Sex • Comorbidity • Language • Asthma duration • Asthma severity • Asthma control
Marteleto, 2008[76] Longitudinal Fair	4,751 individuals aged 14-22 years old at time of Wave 1 of study in Cape Town, South Africa	• Sexual debut • First pregnancy	• Grades completed in 2002 • Enrolled in 2002 • Age • Age squared • Race • Income • Household shock • Mother's education • Father's education • Living with mother • Living with father
Mayben et al., 2007[77] Cross-sectional Fair	119 adults with HIV receiving care at 4 publicly funded clinics in Houston, Texas	• CD4 cell count: median (interquartile range)	• Gender • Reason for getting tested • Marijuana use
Miller et al., 2007[78] Cross-sectional Fair	50 patients at a university community-based internal medicine clinic	• Last time received colon screening	• Age

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Morris et al., 2006[79] Cross-sectional Good	1,002 adults with diabetes in primary care practices in Vermont	• HbA1c level • SBP • DBP • LDL-cholesterol • Retinopathy • Nephropathy • Foot/leg problems • Gastroparesis • Cerebrovascular disease • Coronary artery disease • Depression (unadjusted) • Depression, median Patient Health Questionnaire Score (unadjusted)	• Age • Sex • Race • Marital status • Insurance • Income • Duration of • diabetes • Diabetes • education • Depression • Alcohol use • Medication use • Physician practice
Muir et al., 2008[80] Cross sectional Fair	110 glaucoma patients at a Duke eye clinic in Durham, NC	• VRQoL Score (mean) • Physical HRQoL (SF-12) • Mental HRQoL (SF-12)	• Age • Race • Visual acuity • Visual field • Education
Murray et al., 2009[81] Cohort Fair	192 patients at a university-based public clinic practice in Indianapolis Indiana	• ED Use • Hospitalizations	• Age • Race • Insurance • NYHA class • LVEF • Hematocrit • CHF score • Serum Na, Income • Serum K, Cardiomyo-pathy questionnaire • Comparison Refill adherence Prescription label reading • Depression
Nokes et al., 2007[82] Cross-sectional Fair	489 HIV positive adults receiving care in San Francisco, Fresno, Richmond, NYC, Corpus Christi	• Depressive symptomatology • Distress over body changes • HIV symptom intensity • Global physical health scale (unadjusted)	• Hispanic
Osborn et al., 2007[42] (companions: Wolf et al., 2007;[43] Waite et al., 2008[44]) Cross-sectional Fair	204 patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana	• Non-adherence to HIV medications in past 4 days (self report)	• Race • Gender • Age • Income • Number of medications in HIV regimen • Non-HIV comorbid conditions • Mental illness

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Paasche-Orlow et al., 2005[83] Quasi-experimental/pre-post Fair	73 patients at 2 inner-city hospitals for severe asthma	• Mastery of metered dose inhaler technique • Hospital visits (unadjusted) • ED visits (unadjusted)	• Age • Sex • Ethnicity • Education • Income • History of near fatal asthma • Asthma • Hospitalization in prior 12 months
Paasche-Orlow, 2005[84] Cross-sectional Fair	423 female inmates in Rhode Island adult correctional institute	• HIV Risk Behavior in past 3 months (self-report of sex without a condom or shared injection drug equipment)	• Age • Race • Problem drinking
Paasche-Orlow et al., 2006[85] Retrospective cohort Fair	235 patients with HIV and a history of alcohol problems in Boston, Massachusetts	• 100% adherence to HIV medication regimen (self-report for 3 day period) • Viral load suppressed	• Gender • Age • Education • Randomization group • Ethnicity • Homeless status • Drank to intoxication past 30 days • Injected drugs past 6 months • Complexity of regimen
Pandit et al., 2009[86] Cross-sectional Fair	330 adults with hypertension Receiving primary care from clinics in Grand Rapids, Michigan, Chicago, Illinois, and Shreveport, Louisiana	• Controlled Blood Pressure	• Age • Race • Gender • Marital status • Employment status • Insurance coverage • Site location • Number of comorbid conditions • Years treated for hypertension • Clinic site • Education
Peterson et al., 2007[87] Cross-sectional Fair	99 patients at a community health clinic in Nashville, TN	• Up to date colon screening • Self-efficacy for FOBT • Self-efficacy for colonoscopy	• Age • Sex • Race • Insurance
Powell et al., 2009[88] Cross-sectional Fair	68 patients with Type 2 diabetes treated in general internal medicine clinic	• HbA1c level	• Education • Age • Race • Gender • Treatment regimen

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Powers et al., 2008[89] Cross-sectional Fair	1,224 patients with hypertension receiving primary care in the VA healthcare system and Duke University Healthcare system in Durham, NC	• SBP	• Age • Race • Marital status • Education • Adequacy of income • Diabetic status • Medication Adherence • Smoking • Exercise • Participatory decision-making score
Raehl et al., 2006[90] Cross-sectional Fair	57 seniors in Amarillo, Texas	• MedTake Test: ability to open and take own medications while observed by pharmacist	• Age • Number of over the counter drugs • Owned a car in last 10 years • Received food assistance in last 10 years
Rothman et al., 2006[8] Cross-sectional Fair	200 adults in primary care clinic	• Understanding nutrition labels • Obese (BMI $\geq$ 30) (unadjusted) • Number with chronic illness (unadjusted)	• Age • Gender • Race/ethnicity • Income • Education • Insurance status • Presence of chronic disease • Status of being on a specific diet • Label reading frequency
Schillinger et al., 2006[91] Cross-sectional Good	395 diabetes patients (> 30 years old) treated at one of two primary care clinics at San Francisco General Hospital	• HbA1c	• Age • Primary language other than English • Insurance • Education
Sentell and Halpin, 2006[92] Cross-sectional Fair	23,889 adults in a national sample	• Physical, mental, or other health condition that keeps respondent from working • Long-term illness (greater than 6 months)	• Race • Education • Understand English • Born in U.S.A. • Unemployed • Family income • Income missing • Sex • Age • Married • Get food stamps • Live in Metropolitan Statistical Area • Region

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Shone et al., 2009[93] Cross-sectional Fair	499 children in a New York school district, where over 40% of children live in poverty	• Any urgent care use • Child fair/poor health (adjusted) • Asthma not under good control (unadjusted)	• Ethnicity • Race • Child health Insurance • Parent employment
Smith and Haggerty, 2003[94] Cross-sectional Fair	229 adults in University-affiliated family practice center in Montreal, Canada	• Perceived general health status	• Age • Smoking status • Maternal language
Sudore et al., 2006[95] Prospective cohort, retrospective analysis Good	2,512 well-functioning, Medicare recipients living in the community in Memphis, Tennessee and Pittsburgh, Pennsylvania	• Mortality Rate	• Demographics: (age, race, gender, income, education) • Health status: (self-rated health, cardiac disease, stroke, cancer, hypertension, diabetes, obesity) • Health-related behaviors: (former or current smoker, drinking >1 alcoholic beverage per day) • Poor health care access: (lack of a regular doc or clinic, no flu shot within past 12 months, no insurance for medications) • Psychosocial status: (high depressive symptoms, poor personal mastery)
Sudore et al., 2006[96] Cross-sectional Fair	2,512 well-functioning, Medicare recipients living in the community in Memphis, TN and Pittsburgh, PA	• Influenza shot • Access measures: • No doctor/clinic • No insurance for medication • Composite of access measures • Obesity (BMI $\geq$30) (unadjusted) • Depression (unadjusted) • Hypertension (unadjusted) • Diabetes (unadjusted)	• Age • Race • Sex • Income • Study site • Health status • Cardiac disease • Stroke • Cancer • Hypertension • Diabetes • Obesity • Depressive symptoms
Tang et al., 2008[97] Cross-sectional survey and medical chart review Fair	149 adults with diabetes in diabetes education management center of a public hospital in Hong Kong	• HbA1c level	• Gender • Insurance • Duration of diabetes • Patient awareness score • C-SDSCA (management of diabetes)

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Torres et al., 2009[98] Cross sectional Fair	106 women patients at a family health center in New York City	• Self-efficacy for taking hormone therapy (unadjusted)	• None
von Wagner, 2007[99] Cross-sectional Fair	719 individuals in a national sample of British adults	• Don't smoke • Fruit and vegetable intake ≥ 5/day • Any exercise in the last week	• Age • Education • Gender • Ethnicity • Income
von Wagner et al., 2009[100] Cross-sectional Fair	96 adults in London, England between 50-69 years of age	• Self-efficacy for participating in CRC screening	• Age • Ethnicity • Employment • Gender • Number of computer links open • Mean reading time • CRC screening knowledge
Walker et al., 2007[101] Cross-sectional Fair	363 patients at 3 rheumatology clinics in the United Kingdom	• Hospital Anxiety and Depression scales (HAQ and HAD)	• None
Waite et al., 2008[44] (Companions: Osborn et al., 2007;[42] Wolf et al., 2007[43]) Cross-sectional Fair	204 patients at 2 HIV clinics, 1 in Chicago, IL and 1 in Shreveport, LA	• Non-adherence to HIV medications in past 4 days (self report)	• Mediator: Stigma concerns related to HIV medications (self report) • Age • Gender • Site • Employment status • Number of medications in HIV regimen • Number of non-HIV prescription medications taken • Comorbid chronic condition • Treatment for mental health condition • Treatment for substance abuse
Weiss et al. 2004[102] Retrospective cohort Fair	74 Medicaid beneficiaries in Arizona	• Total Medicaid costs, 1 year period	• Age • Ethnic group • Health status
White et al., 2008[103] Cross-sectional Fair	18,100 participants in nationally representative US sample living in households	• Colon cancer screen • Mammography • Had flu shot • Vision check-up • Dental check-up • Prostate screening • Osteoporosis screening	• Age • Gender • Race • Poverty level • Insurance • Health status • Oral reading fluency

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Wolf et al., 2005[39] Cross-sectional Fair	3,260 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Physical function (SF-36) • Mental health functioning (SF-36) • Hypertension • Asthma • Bronchitis or emphysema • Heart failure • Coronary artery disease • Diabetes • Arthritis • Cancer • IADL • Activity limitations • Limitations due to physical health • Pain interfering with activities	• Age • Sex • Race/ethnicity • Income • Education • Tobacco • Alcohol consumption • Self-reported comorbid conditions
Davis et al., 2006[45] Cross-sectional Fair	395 adults in primary care clinics in Shreveport LA, Jackson MI, and Chicago, IL	• Misunderstood one or more prescription label instructions • Correct demonstration of number of pills	• Age • Sex • Race • Education • Number of medications currently taken daily • Site
Wolf et al., 2007[46] Cross-sectional Fair	395 adults in primary care clinics in Shreveport LA, Jackson MI, and Chicago, IL	• Correctly interpreted primary prescription label (unadjusted) • Correctly attended to auxiliary label (unadjusted)	• None
Wolf et al., 2006[104] Cross-sectional Good	308 patients with newly diagnosed prostate cancer in 4 outpatient oncology and urology clinics in Chicago area	• PSA Level > 20 ng/mL	• Age • Race • Annual income • Marital status
Wolf et al., 2006[105] Cross-sectional Fair	251 adults at a primary care clinic in Shreveport, Louisiana	• Read/looked at medication guides and consumer information included with prescription medications	• Age • Gender • Race • Education • Number of prescriptions taken

Table 5. Overview of health literacy studies (continued)

Source Design Quality Score	Population	Outcomes	Potential Confounders Controlled in Analysis
Wolf et al., 2007[43] Cross-sectional Fair	204 patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana	• Non-adherence to HIV medications in past 4 days (self report) • Perception of self-efficacy to properly take and manage HIV medications	• Mediator: HIV treatment knowledge • Mediator: HIV medication self-efficacy • Age • Insurance coverage • Employment status • Number of medications in HIV regimen • Number of non-HIV prescription medications currently taking • Presence of comorbid chronic conditions • Treatment for mental health condition past 6 months • Treatment alcohol or drug use past 6 months
Wolf, 2007[37] Cross-sectional Fair	2,923 new Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami)	• Smoking (never, former, or current) • Current alcohol use (none, light to moderate, or heavy) • Level of physical activity per week • Seat belt use (unadjusted)	• Age • Gender • Race/ethnicity • Language (English or Spanish) • Site • Education • Annual income • Occupation (white or blue collar)
Yin et al., 2007[106] Cross-sectional Fair	292 parents/ caregivers of children at an Emergency Department in New York City	• Self reported use of nonstandardized dosing instrument	• Experience of ever receiving a dosing instrument in a health care setting • Child's age • Child has regular health care provider • Confounders with health literacy: • Caregiver's education, country of origin, language, socio-economic status

Most studies had cross-sectional design (53), but 15 were cohort designs (Table 5). Because the current measures of health literacy and numeracy are static (i.e., an individual's level in adulthood is unlikely to change appreciably over time), we can typically assume that the measured health literacy level predated the health outcome and would remain constant after the measured outcome. This assumption is obviously untrue in children and also may not necessarily apply to elderly adults, in whom health literacy and numeracy skill levels may change over time.

Additionally, medical illness may affect health literacy and numeracy more profoundly in these groups than in nonelderly adults.

In contrast to our earlier review, studies reviewed in the update by and large include multivariate analyses (rather than just unadjusted bivariate analyses) (Table 5). However, the choice of confounders controlled in analyses varied greatly across studies. Potential confounders (related to health literacy and health outcomes) controlled for in a number of studies include education, age, health insurance, race, gender, and income.

Table 6 groups KQ 1 studies based on the health literacy measurement tool used in the analysis and further, the skill level groupings used to distinguish study participants. We found that health literacy was mostly measured with the REALM (30 articles) or the TOFHLA or S-TOFHLA (37 articles). Two articles used the NAAL and unlike our earlier review, no article used the WRAT (a general literacy measure that was commonly used in studies included in our earlier review *Literacy and Health Outcomes*[1]). Several other literacy measures (in contrast to health literacy measures intended to be used in a health care environment) were included in one study apiece: the Cape Area Panel Study Literacy and Numeracy Evaluation, a reading comprehension instrument in Napalese, an Instrument for the Diagnosis of Reading, and the Woodcock Language Proficiency Battery. Information about these measures is quite limited. The health literacy levels used to compare study participants evaluated using the REALM, TOFHLA or S-TOFHLA varied among studies, ranging from a continuous measure to two, three or even more groups. In some studies, while three groups were identified (i.e., inadequate, marginal, and adequate), in others, two of the three groups were combined in the statistical analysis. Studies varied concerning whether the two lower or the two higher groups are combined.

Table 6. Measurement tools and criteria used to measure health literacy or literacy in KQ 1 articles

Study	Measurement Tool	Measurement Levels (Continuous or Cut-points)
Marteleto, 2008[76]	Cape Area Panel Study Literacy and Numeracy Evaluation	Continuous
Weiss, 2004[102]	Instrument for the Diagnosis of Reading (IDR-English/Spanish)	≤ 3rd grade, > 3th grade
Hope, 2004[64]	Medication Skills Assessment (Reading Score)	0= no correct answers, 1= some correctly answered questions, 2= correctly answered all questions
Sentell, 2006[92]	National Adult Literacy Survey (NALS) literacy and numeracy	Continuous
Bennett, 2009,[50] White, 2008[103]	National Assessment of Adult Literacy (NAAL)	Below basic, Basic, Intermediate, Proficient
Levine, 2004[71]	Reading comprehension and academic language proficiency (noun definitions) in Napalese	No school, 1-4 years, 5-9 years, 10+ years
Barragan, 2005[48]	Rapid Estimate of Adult Literacy in Medicine (REALM)	Low or ≤ 6th grade, Not low or > 6th grade

Table 6. Measurement tools and criteria used to measure health literacy or literacy in KQ 1 articles (continued)

Study	Measurement Tool	Measurement Levels (Continuous or Cut-points)
Graham, 2007,[57] Huizinga, 2008,[65] Lindau, 2006,[73] Peterson, 2007,[87] Powers, 2008,[89] DeWalt, 2007,[53] Lincoln, 2006,[72] Muir, 2008,[80] Shone, 2009,[93] Sudore, 2006,[95] Miller, 2007,[78] Rothman, 2006,[8] Walker, 2007[101]	Rapid Estimate of Adult Literacy in Medicine (REALM)	< 9th grade (score: 0-60), ≥ 9th grade (score: 61-66)
Nokes, 2007,[82] Raehl, 2006,[90] Smith 2003[94]	Rapid Estimate of Adult Literacy in Medicine (REALM)	Continuous
Paasche-Orlow, 2006,[85] Paasche-Orlow, 2005,[84] Davis, 2006,[45] Kripalani, 2006,[68] Wolf, 2006,[104] Osborn, 2007,[42] Wolf, 2006,[105] Wolf, 2007,[43] Sudore, 2006,[96] Waite, 2008,[44] Wolf, 2007[46]	Rapid Estimate of Adult Literacy in Medicine (REALM)	Low or < 6th grade (Score: 0-44), Marginal or 7th-8th grade (Score: 45-60), ≥ Adequate or 9th grade and above (Score: 61-66)
Powell, 2009,[107] Estrada, 2004[54]	Rapid Estimate of Adult Literacy in Medicine (REALM)	≤ 3rd grade, 4th-6th grade, 7th-8th grade, ≥ 9th grade
Baker, 2004,[35] Baker, 2007,[38] Wolf, 2007,[37] Baker, 2008,[40] Howard, 2006,[36] Wolf, 2005[39]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate (0-55), Marginal (56-66), Adequate (67-100)
Chew, 2004,[51] Torres, 2009,[98] Raehl, 2006[90]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate (0-16), Marginal (17-22), Adequate (23-36)
Gazmararian, 2006,[34] Howard, 2005[41]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate (0-53), Marginal (54-66), Adequate (67-100)
Grubbs, 2009,[58] Cho, 2008,[52] Guerra, 2005,[59] Guerra, 2005,[60] Hironaka, 2009,[63] Lee, 2009[70]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate/Marginal (0-22), Adequate (23-36)
Laramee, 2007[69]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Limited (inadequate/marginal, 0-22), Adequate (23-36)
Morris, 2006[79]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate (0-16), Marginal (17-22), Adequate (23-36) and continuous measurement
Paasche-Orlow, 2005[83]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Inadequate (0-16), Marginal/Adequate (17-36)

Table 6. Measurement tools and criteria used to measure health literacy or literacy in KQ 1 articles (continued)

Study	Measurement Tool	Measurement Levels (Continuous or Cut-points)
Pandit, 2009[86]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Category I: 0-30, Category II: 31-50, Category III: 51-70, Category IV: 71-90, Category V: 91-100
Schillinger, 2006,[91] Raehl, 2006,[90] von Wagner, 2007,[99] Hibbard, 2007[62]	Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Continuous
Tang, 2007[97]	Short Test of Functional Health Literacy in Adults (S-TOFHLA) (Chinese)	Continuous
Fang, 2006[55]	Short Test of Functional Health Literacy in Adults (S-TOFHLA) (English or Spanish)	Limited (inadequate/marginal, 0-22), Adequate (23-36)
Bennett, 2007[49]	Short Test of Functional Health Literacy in Adults (S-TOFHLA) (Spanish)	Inadequate (0-55), Marginal (56-66), Adequate (67-100)
Murray, 2009[81]	Short Test of Functional Health Literacy in Adults (S-TOFHLA) and Prescription label reading test	Inadequate (0-16), Marginal (17-22), Adequate (23-36) 0= no correct answers, 1= some answers correct, 2= correctly answered all questions
Johnston, 2005,[108] Mayben, 2007,[77] Mancuso, 2006,[74] Mancuso, 2006[75]	Short Test of Functional Health Literacy in Adults (TOFHLA)	Inadequate/Marginal (combined; 0-74), Adequate (75-100)
Kalichman, 2008[67]	Short Test of Functional Health Literacy in Adults (TOFHLA)	Higher literacy (90% correct or 45 of 50 questions correct), Lower literacy (<90% correct or < 45 correct)
Yin, 2007,[106] (English or Spanish), Garbers, 2004[56] (Spanish)	Short Test of Functional Health Literacy in Adults (TOFHLA)	Inadequate (0-59), Marginal (60-74), Adequate (75-100)
von Wagner, 2009[100]	United Kingdom Test of Functional Health Literacy in Adults (UK-TOFHLA)	Continuous
Hahn, 2007[61]	Woodcock Language Proficiency Battery (passage comprehension subtest)	< 7th grade, ≥ 7th grade

KQ 1a. Use of Health Care Services

We identified 34 articles reporting on 33 unique studies examining the relationship between health literacy skills and the use of health care services. Three studies were of good quality and 20 were fair quality. Six studies included cohort designs; the rest were cross-sectional. These studies focused on emergency department admissions or hospitalizations, general preventive screening, and access to office visits and general care.

Hospitalization and emergency department rates. Five studies—one good quality prospective cohort study (hereafter, the Prudential study),[41] one fair quality prospective cohort study,[81] one retrospective cohort study,[53] one pre-post study[83] and one cross-sectional study[52]—examined the risk of hospitalization by health literacy level. Table 14 describes these studies. All five studies showed a statistically significant association of increased hospitalization and use of inpatient services with lower health literacy level. The strength of evidence is moderate (Table 7 and Appendix E). Populations included the elderly,[41,52] patients with asthma,[53,83] and patients with congestive heart failure.[81] The Prudential study examined the impact of low health literacy on medical care use among 3,260 Prudential Medicare managed-care enrollees.[41] Patients with low health literacy had higher probabilities of using inpatient services than those with adequate health literacy (mean differences in probability of use, 0.05; 95% Confidence Interval [CI] 0.00-0.09). Enrollees with marginal and adequate health literacy did not differ in use of inpatient services. These findings are consistent with previous findings in our 2004 systematic review.[1]

Eight studies, including two good quality prospective studies,[35,41] two other prospective cohorts,[64,81] one retrospective cohort,[53] one pre-post study,[83] and two cross-sectional studies[52,93] examined emergency and urgent care visits by literacy level (Table 14). All but one study[93]showed an association of greater emergency department use and low health literacy. The strength of evidence is moderate (Table 7 and Appendix E). No studies of emergency department use were reported in our earlier report. The Prudential study,[35] examined the association of emergency department visits with health literacy level. After controlling for multiple confounders, both the inadequate health literacy and marginal health literacy groups had a higher rate of two or more emergency department visits when compared with those with adequate health literacy (marginal literacy relative risk [RR], 1.44; 95% CI, 1.01-2.02; inadequate literacy, RR, 1.34; 95% CI, 1.00-1.79).

The one study that did not find an association with health literacy examined associations of parent health literacy and child asthma care among children with persistent asthma.[93] This cross-sectional study of 499 children with persistent asthma examined parental health literacy and multiple aspects of asthma care (preventive medicine use, acute care, unmet needs, parental worry, and parental quality of life). Parental health literacy was not associated with children's use of any urgent care. This particular outcome was limited because the outcome of urgent care visits was measured by parental self-report.

General screening. We found one good[50] and seven fair studies[52,56,59,60,78,87,103] examining the association of health literacy with general screening services. These services included colon screening (Table 15), Papanicolau test (Pap smears, (Table 16), mammography (Table 17), and testing for sexually transmitted diseases (Table 18).

Colon screening. Five cross-sectional studies found mixed results for the probability of having received colon screening by health literacy level (Table 15).[52,59,78,87,103] The strength of evidence is low (Table 7 and Appendix E). Of note, the two larger studies found a lower probability of colon screening in patients with lower health literacy.[52,103] The largest study, by White et al.[103] found a decreased probability of colon cancer screening among those 65 years of age and older with below basic health literacy compared with those with proficient skills in a nationally representative US cross-sectional study of 18,100 individuals examining multiple self-reported preventive services (data not reported [NR]; $P < 0.05$). The three studies not finding an

Table 7. KQ 1 health literacy studies: strength of evidence grades by use of health care services outcomes

Outcome for Health Literacy Studies	Number of Studies	Results	Strength of Evidence Grade
Hospitalization	5	Low literacy associated with Increased hospitalization	Moderate
Emergency care visit	8	Low literacy associated with greater emergency care use except in one study of urgent care visits (measured by self- report)	Moderate
Colon screening	5	Mixed results, larger studies found lower probability of screening	Low
Pap smears	3	Low literacy associated with decreased probability of ever having a Pap smear	Low
Mammography	4	Low literacy associated with less use of mammography; measures and populations differed across studies	Low
Sexually transmitted infection testing	1	Low literacy associated with greater odds of accepting HIV testing	Low
Immunization: Influenza	4	Low literacy associated with lower probability of receipt of influenza vaccine	Moderate
Immunization: pneumococcal	1	Mixed results	Low
Access to care	7	Mixed results. No association with number of physician visits. Mixed for dental and vision visits.	Insufficient

association with health literacy were smaller in size (samples of 50 to 136) and limited to one geographic area.[59,78,87] No studies of colon screening use were reported in the earlier 2004 report.[1]

Pap tests. Three cross-sectional studies found that women with lower health literacy had a lower probability of ever having had a Pap test (Table 16).[52,56,103] However, this result was present only in certain age cohorts. Thus, overall strength of evidence is low (Table 7 and Appendix E). In a nationally representative sample, White et al. found that women less than 40 years of age with below basic health literacy had a lower probability of having a Pap test than women in the same age group with proficient health literacy (NR, $P < 0.05$), but the probabilities did not differ by literacy level in women 40 to 64 years of age.[103] Results also seemed to differ by degree of low health literacy (inadequate vs. marginal). Garbers et al. examined Pap screening in 205 low-income Spanish-speaking Latinas in New York City.[56] In adjusted analyses, controlling for age, years in the United States, education, having a source of care and health insurance, these investigators found that women with inadequate health literacy were less likely to have ever have a Pap test than women with adequate literacy (odds ratio [OR], 0.06; 95% CI, 0.01-0.55). However, the marginal and adequate health literacy groups did not differ significantly (OR, 0.14; 95% CI, 0.01-1.41). This discrepancy in findings between inadequate and marginal groups is consistent with an earlier study[109] in the 2004 report.[1]

Mammography. Four cross-sectional studies examined use of mammography by health literacy group (Table 17).[50,52,60,103] All studies found a lower use of mammography in the lower

health literacy group compared with the adequate group. However, one study found a difference in receipt of mammograms among older women[103] and another found differences between groups by frequency of mammograms.[60] In the Prudential study, women 65 and older with low health literacy had a lower probability of having a mammogram than those with adequate health literacy (NR, $P < 0.05$); health literacy was not associated with the probability of having mammography among women ages 40 to 64.[103] Guerra et al. evaluated mammography rates in 97 women in three community health clinics in Philadelphia; inadequate health literacy was associated only with a significantly lower odds of ever having a mammogram (OR, 0.88; 95% CI, 0.79-0.98) but not with having a mammogram in the past year, past 3 years, or as part of a check-up.[60] The strength of evidence is low (Table 7 and Appendix E). These results are consistent with the 2004 report.

Sexually transmitted infections. Barragan et al. conducted a cross-sectional study (N = 372) of HIV test acceptors in an inner city urgent care hospital (Table 18).[48] Subjects with inadequate health literacy had greater odds of accepting an HIV test result than those with adequate health literacy (OR, 2.02; 95% CI, 1.19-3.42). In the 2004 report, the one study about this type of service showed a lower probability of having received a gonorrhea test in the past year among those in the low literacy group.[110] The strength of evidence is low (Table 7 and Appendix E).

Immunizations. One good cohort[36] and three cross-sectional studies[50,96,103] found inadequate health literacy associated with lower receipt of influenza vaccine (Table 19). The strength of evidence is moderate (Table 7 and Appendix E). In Prudential study analyses, Howard et al. controlled for age, sex, race, ethnicity, education, income, site, morbidity, and smoking; they found a lower odds of receiving an influenza vaccine in the inadequate health literacy group than in the adequate group (OR 0.76, $P = 0.020$), but no significant differences in the marginal health literacy group compared with the adequate health literacy group.[36] These findings are similar to those in our 2004 report. Age also appears to be a factor in White et al.[103] which found a lower receipt of influenza vaccine by health literacy level among adults under 40 years and 65 or older (NR, $P < 0.05$), but no differences by health literacy level in adults at 40 to 64 years of age (P = NS, NR).

Pneumococcal vaccine did not follow a pattern similar to influenza vaccine (Table 20). The strength of evidence is low (Table 7 and Appendix E). In the two studies that examined pneumococcal vaccine,[36,103] no significant association between pneumococcal vaccine and health literacy level were found.

Access to office visits and general care. Four cohort[35,41,58,73] and three cross-sectional studies[62,74,75,96,103] examined various measures of access to office visits and general care; these types of services included pharmacy visits, dental visits, and vision checkups as well as hospital choice and transplant waitlists (Table 20). The strength of evidence is insufficient (Table 7 and Appendix E). Two good cohort analyses from the Prudential study did not find an association of inadequate health literacy level with number of physician visits[35] or pharmacy service used.[41] These results are consistent with the one study[111] described in the 2004 report. Similarly, one prospective cohort of 68 individuals did not find differences in time to follow up after an abnormal Pap smear by health literacy level.[73] Results were mixed for dental and vision visits in one Prudential study analysis.[103]

One interesting retrospective cohort study involved 62 patients in five outpatient dialysis units in San Francisco, California.[58] After controlling for multiple confounders, the investigators found a significantly longer time from start of dialysis to referral to a transplant list in patients with inadequate health literacy (hazard ratio [HR], 4.54; 95% CI, 1.67-12.5). However, they saw

no subsequent differences in time from being on transplant list to making the waitlist for transplant.

Summary of Outcomes on Use of Health Care Services

Differences in health literacy level were associated with use of some health care services (Table 7). Specifically, lower literacy was associated with increased emergency department and hospital use, less screening for cervical cancer (through a Papanicolau test [Pap smear]) and breast cancer (mammography) and lower influenza immunization. Evidence was mixed for pneumococcal immunization and access to office visits. The strength of evidence to support these findings was moderate for hospitalizations, emergency department visits, and influenza immunization. Evidence for other health care service use was low or moderate because of inconsistent findings and outcomes.

KQ 1b. Health Outcomes

We identified 58 articles reporting on 45 unique studies examining the relationship between literacy skills and health outcomes. Of these, 10 articles were of good quality, and 48 were fair quality.

Adherence. Nine studies, reported in 11 articles with a low strength of evidence (Table 8 and Appendix E), evaluated the relationship between health literacy level and adherence in adjusted analyses (Table 21).[34,42-44,51,52,55,57,63,67,85] Generally, they found mixed evidence of a relationship between health literacy and health outcomes, which may be related to differences in adherence measure, disease state, and adjustments for relevant confounders. Of these, eight articles focused on medication taking adherence, 2 on refill adherence, and 1 on adherence to procedural instruction.

Table 8. KQ 1 health literacy studies: strength of evidence grades by health outcomes

Outcome for Health Literacy Studies	Number of Studies	Results	Strength of Evidence Grade
Adherence	9	Mixed results depending on adherence measure, disease state, and adjustment for confounding	Low
Self-efficacy	4	Mixed results in studies conducted within various sub-populations	Low
Smoking	2	Mixed results	Low
Alcohol use	1	No effect on current alcohol consumption	Low
Healthy lifestyle (physical activity, eating habits, and seat belt use)	4	Mixed results from 1 study each on exercise, diet, a composite measure, and seatbelt use	Low

Table 8. KQ 1 health literacy studies: strength of evidence grades by health outcomes (continued)

Outcome for Health Literacy Studies	Number of Studies	Results	Strength of Evidence Grade
Healthy lifestyle (obesity and weight)	4	Mixed results, all unadjusted	Insufficient
Review of prescription information	1	Low literacy associated with being less likely to read prescription information	Low
HIV risk and sexual behaviors	2	Mixed results	Low
Taking medications appropriately	4	Mixed results	Low
Interpreting labels and health messages	3	Low literacy associated with poorer ability to interpret labels and health messages; smaller likelihood of giving an organized health narrative	Moderate
Asthma self-care	1	Low literacy associated with poorer self-care skill in 1 study	Low
Mental health outcomes	8	Results in 7 of 8 studies found association between lower literacy and depression	Moderate
Chronic disease outcomes	6	Mixed results: 3 studies on association with chronic diseases generally 3 studies on association with specific diseases	 Low Low
HIV severity and symptoms	4	Mixed results; 3 of 4 studies found no relationship; outcomes varied across studies	Low
Asthma severity and control	2	Mixed results; only unadjusted analysis of asthma control	Insufficient
Diabetes control and related symptoms	5: 4 glycemic control, 1 compli-cations	Glycemic control: mixed results Complications: no relationship	Low Low
Hypertension control	2	Mixed results	Low
Prostate cancer control	1	More likely to have higher PSA test results (worse levels)	Low
Health status: all adults	1	No relationship with global health status	Low
Quality of life: seniors	4	Lower overall health status Mixed effects mental and physical functioning	Overall: Moderate Mental and physical: Low
Quality of life: individuals with specific diseases	5	Mixed results: mental and physical functioning by disease state and measure	Low
Mortality: seniors	2	Higher risk of mortality in the lower literacy group. Risk not elevated in the marginal literacy group (1study)	High

Four studies reported in 6 articles examined non-adherence in taking HIV medication and found limited evidence of a direct relationship.[42-44,57,67,85] In one study examining 100 percent adherence to medications over 3 days, Paache-Orlow et al. found no relationship between health literacy and adherence among HIV patients with a history of alcohol problems.[85] In another study using self-reported pill counts and controlling for education and other potential confounding variables, Kalichman et al. found a positive relationship between lower health literacy level (measured as a *Test of Functional Health Literacy in Adults* [TOFHLA] score of less than 90 percent correct, rather than more commonly used categories) and probability of non-adherence (OR, 3.77; 95% CI, 1.46-9.93).[67] Osborne et al. also found a positive relationship: non-adherence to HIV regimen was higher among those with low health literacy than those with adequate health literacy, among 204 patients receiving care in two clinics (OR, 2.12; 95% CI, 1.93 - 2.32).[42] However, subsequent analyses of the Osborne et al. sample showed that this relationship was mediated by the combination of HIV treatment knowledge and medication self-efficacy in one analysis,[42] and by stigma related to taking HIV medications in another;[44] health literacy level was no longer a significant predictor of adherence when the investigators also controlled for these variables in their analyses. In another analysis intended to examine a potential mediator of the relationship between health literacy level and adherence, Graham et al. did not find a significant difference in adherence between low and adequate health literacy groups in a small sample (N = 87) controlling for just the patient's belief about an acceptable level of adherence.[57]

Medication taking adherence, refill adherence, and adherence to procedural instructions were examined in various other patient populations with mixed results. Among 110 caregivers of infants in pediatric clinics, a combined group of those with low or marginal health literacy were significantly *more* likely to be adherent in providing vitamins to their infants than those with adequate health literacy (OR, 2.4; 95% CI, 1.37-4.2).[63] However, no significant differences by health literacy level emerged in other patient populations for medication taking, refill adherence, or adherence to procedural instructions. Studies include patients at a anticoagulation clinic missing doses of warfarin,[55] seniors at two clinics filling any medication prescriptions on time,[52] seniors refilling medications for cardiovascular disease,[34] and preoperative clinic patients following fasting and preoperative medication instructions.[51]

Only one study examining the relationship between health literacy level and adherence assessed outcome differences between individuals in the marginal and adequate health literacy groups. The research team found no significant difference.[42-44]

Our earlier review also found mixed results across studies. One study reported a significant relationship between lower literacy and poorer self-reported adherence; three found no significant relationship.[112-115]

Self-efficacy. Four studies examined participant health literacy level and self-efficacy. Studies generally found greater self-efficacy to be related to higher health literacy level[43,87,98,100] (Table 22). However, the strength of evidence is low (Table 8 and Appendix E) due to some mixed results. Among patients on HIV medications, Wolf et al. found greater self-efficacy in the adequate health literacy group than in the low literacy group, controlling for potential confounders, but they did not find any difference between the adequate and marginal groups.[43] Von Wagner et al. found greater self-efficacy to be related to higher health literacy level (measured by the UK TOFHLA) in relation to colorectal cancer screening, controlling for confounders including knowledge.[100] Higher self-efficacy for taking hormone therapy among postmenopausal women was also correlated with higher health literacy level in an unadjusted

analysis.[98] In contrast, self-efficacy for obtaining a fecal occult blood test or colonoscopy was not related to health literacy level when low and marginal health literacy groups (called limited) were combined and compared with a group with adequate literacy in a small, potentially underpowered adjusted analysis of 99 patients at one clinic.[87] Our earlier review had no self-efficacy studies.

Health Behaviors. We identified studies reporting on a variety of health behaviors including smoking, alcohol use, healthy lifestyle, HIV risk behaviors and sexual activity.

Smoking. Two large studies evaluated the relationship between health literacy level and self report of smoking in adjusted analysis (Table 23); results were statistically different even though odds ratios were fairly similar.[37,99] Due to the mixed results, the strength of evidence was graded as low (Table 8 and Appendix E). Von Wagoner et al. examined current smoking status in a national sample of British adults (N = 719) and found that higher health literacy, measured as a continuous variable, was associated with a small increased likelihood of not smoking (OR, 1.02; 95% CI, 1.003-1.03).[99] In contrast, among the Prudential sample of American seniors (N = 2,923), Wolf et al. found no relationship between health literacy level and participants' smoking status (never, former, or current).[37] We reported mixed results in our earlier review through two unadjusted analysis examining outcomes of smoking in adults.

Alcohol use. Wolf et al. also examined the relationship between health literacy level and current alcohol consumption; they found no relationship.[37] With only one study, strength of evidence was graded as low (Table 8 and Appendix E). We included no study of alcohol consumption in adults in our earlier review.

Healthy lifestyle. We also reviewed the relationship between health literacy level and various measures of healthy lifestyle including level of physical activity, eating habits, seat belt use and weight (Table 23). Overall, the strength of evidence was low (Table 8 and Appendix E) for the relationship between health literacy and physical activity, eating habits, and seat belt use as a group. The strength of evidence concerning weight or obesity was insufficient (Table 8 and Appendix E).

The von Wagoner et al. and Wolf et al. studies, discussed above for smoking outcomes, measured level of physical activity. Neither study found significant differences by health literacy level.[37,99]

In a sample of British adults, higher health literacy level was associated with a small but significantly higher probability of eating five or more servings of fruits or vegetables per day (OR, 1.02; 95% CI, 1.003-1.03).[99]

Among 489 seniors receiving care at two clinics in Chicago, health literacy level did not have a direct effect on a composite measure, the Health Promoting Lifestyle Profile, which assesses a combination of exercise, nutrition, and health responsibility.[52]

Only one unadjusted analyses examined the relationship between health literacy level and seat belt use. They found no significant differences.[37]

Four studies examined differences in rates of obesity or body mass index (BMI) by health literacy level in unadjusted analyses.[8,38,65,96] Results were mixed.

Our earlier review had no studies with any healthy lifestyle outcomes.

Review of prescription information. One adjusted analysis examined the relationship between health literacy and review of prescription information (Table 23). The strength of evidence was low (Table 8 and Appendix E). Clinic patients (N = 251) in Shreveport, Louisiana, were asked to report on whether they ever looked at the consumer information included with their prescriptions.[105] After controlling for potential confounders, including the number of

prescriptions taken, those with low health literacy were more likely not to look at the material than persons of adequate health literacy (OR, 2.5; 95% CI, 1.2-5.2). The marginal and adequate health literacy groups did not differ.

HIV Risk Behaviors and Sexual Activity. Two adjusted analyses examined the relationship between health literacy and sexual behaviors (Table 23). The strength of evidence was low (Table 8 and Appendix E). One study of female inmates did not find a relationship between health literacy level and HIV risk behaviors (sex without a condom or sharing injecting equipment), controlling for age, race, and problem drinking.[84]

A large study of adolescents and young adults (N = 4,751) in Cape Town, South Africa, found that higher literacy level (measured using the Cape Area Panel Study Literacy and Numeracy Evaluation) was associated with a lower probability of sexual debut but not first pregnancy, controlling for socioeconomic variables.[76]

Health care-related skills. Eight studies reported in 9 articles included outcomes concerning a variety of health care-related skills (Table 24). Among these were appropriate medication use,[54,68,90,106] interpreting prescription medication, nutritional labels, and health messages;[8,45,71] and asthma self-care skills.[83] The strength of evidence concerning taking medications appropriately and asthma self-case was low, while the strength of evidence concerning interpreting labels and health messages was moderate (Table 8 and Appendix E).

Two studies directly observed whether participants could take medications appropriately; their results were mixed. Kripalani et al., in a study we rated good quality, required 152 coronary heart disease patients to perform four tasks relating to their medication: identify the appropriate medication, open the container, select the correct dose, and report the appropriate timing of doses.[68] The researchers found no difference across health literacy levels in patients' scores from completing all four tasks in an unadjusted analysis. However, after controlling for age, education, and cognitive functioning, low health literacy (but not marginal health literacy) was associated with poorer performance on one of the tasks—being less likely to identify all of one's medications (OR, 12.00; 95% CI, 2.57-56.08). Similarly, in a small sample of seniors in Texas (N = 57), researchers found that lower health literacy score (measured continuously) was associated with poorer ability to open and take one's own medications in adjusted analysis.[90]

Two additional adjusted analyses examined whether patients take medications properly, the first through self report and the second, through biologic test results and found limited evidence of a relationship with health literacy level.[54,106] Yin et al. examined whether health literacy level was associated with parents' use of a nonstandardized dosing instruments (such as kitchen spoons) when providing medications to their children; they found no relationship in an analysis adjusting for all identified potential confounding variables.[106] However, after removing only the variables in the analysis that were confounded with health literacy level, participants with marginal/inadequate health literacy (combined into one group) were more likely to use a nonstandardized instrument than those with adequate health literacy (OR, 1.9; 95% CI, 1.0-3.5). One study examined warfarin control measured by international normalized ratio (INR) variability. Results did not differ by health literacy level, controlling only for age, in a population of adults 50 years of age and older.[54]

Two studies examined participants' ability to interpret labels (prescription and nutrition); both found a positive relationship with health literacy level. One study among 395 adult patients in three primary care clinics in Shreveport, Louisiana, Jackson, Mississippi, and Chicago, Illinois, examined interpretation of prescription medication labels.[45,46] Participants described medication label instructions to physicians; in adjusted analyses, those with inadequate health

literacy (RR, 2.32; 95% CI, 1.26-4.28), as well as those with marginal health literacy (RR, 1.94; 95% CI, 1.14-3.27) had a greater probability of misunderstanding one or more labels than those with adequate health literacy.[45] A further (unadjusted) examination of participants' correct interpretation of each of the five primary and auxiliary labels found significant differences in interpretation of primary labels between groups for four of five primary medication labels and two of five auxiliary labels.[46] Similarly, Rothman et al. found in an adjusted analysis that those with lower health literacy (less than high school level) were less likely to understand nutrition labels.[8]

One study examined health literacy and the ability to give an organized oral health narrative. Among community sample of mothers of young children in Nepal, in an adjusted analysis, higher literacy level was associated with greater ability to give an organized health narrative (a skill associated with higher oral health literacy).[71]

One study examined self-care skills relating to asthma among hospitalized adults.[83] In adjusted analysis, those with inadequate health literacy, compared with those with adequate literacy, were less likely to have mastery of their dose inhaler (OR, 0.29; 95% CI, 0.08-1.00). We had found a similar result in our earlier review.

Disease prevalence and severity. We found multiple studies examining the relationship between health literacy level and disease prevalence (specifically mental health diagnoses and chronic conditions) and to disease severity (specifically in relation to HIV, asthma, diabetes, hypertension, and prostate cancer).

*Mental health outcomes***.** Seven of eight studies evaluating the relationship between depression and health literacy level found that patients with lower health literacy were more likely to have symptoms of depression or to be considered depressed; however, the majority of studies controlled for a limited number or no potential confounders[41,49,67,72,79,82,96,101] (Table 25). The strength of evidence was moderate (Table 8 and Appendix E). In the most rigorous analysis, a prospective cohort design, conducted among 390 patients receiving inpatient detoxification from alcohol and substance abuse, depression symptomatology did not differ between health literacy groups at baseline but was higher among those with lower health literacy at 2-year followup, controlling for a number of potential confounders including socio-demographic characteristics, primary substance of choice and mental state.[72] Other analyses were conducted among subpopulations with limited adjustments for potential confounders; one reported that depression was greater in the lower health literacy group among HIV-positive adults in five urban clinics, controlling for Hispanic nationality[82] and in a second, depression was also greater among lower (but not marginal) health literacy pregnant patients controlling for Mexican nativity and marijuana use.[49] In unadjusted analyses, lower health literacy was also related to depression among rheumatology and diabetes patients[79,101] and among seniors in two community samples.[41,96] However, no difference by health literacy level was found among HIV-positive patients in Atlanta.[67] Results of studies evaluating differences in depression across different levels of health literacy in our earlier review were mixed, including among the two studies that controlled for potential confounders.

Chronic disease outcomes and prevalence. Three studies examined differences in rates of chronic disease (defined in a group as any long-term illnesses) by health literacy level (Table 26).[8,38,92] Three additional studies examined differences in rates of specific diseases by health literacy level.[39,41,96] Overall, the body of evidence found mixed results and was limited by differences in outcomes across studies with the majority of studies not controlling for potential

confounders. Given these issues, the strength of evidence was graded low (Table 8 and Appendix E).

With regard to chronic disease, Sentell et al. using the large, nationally representative National Adult Literacy Survey (NALS) (N = 23,889) and controlling for various sociodemographic characteristics including education, found that lower health literacy was associated with higher odds of having a long-term illness (one lasting more than 6 months) and greater odds of having a condition that would keep the individual from working.[92] In unadjusted analyses, the number of chronic conditions among seniors and percentage with a chronic disease among adults in a clinic population did not differ by health literacy level.[8,38]

Two studies, discussed in three articles examined differences in rates of specific diseases by health literacy level; one used a well-designed adjusted analysis and the others used unadjusted analyses.[39,41,96] All analyses were limited to senior citizens. In adjusted good-quality analyses of the Prudential sample, inadequate compared with adequate health literacy was associated with significantly higher rates of diabetes and heart failure, but not with higher rates of hypertension, coronary heart disease, bronchitis, asthma, arthritis, or cancer.[39] In contrast, the investigators found no differences in rates of specific diseases between those with marginal and adequate health literacy. Potential limitations of this analysis are that respondents' outcomes are self-reported shortly after joining the health plan and differences in prior access to care may have resulted in differences in knowledge concerning their disease state. Also, by testing multiple outcomes, significant differences were more likely to be found in at least some of the comparisons. Two unadjusted analyses measured the probability of differences in prevalence of chronic disease across three health literacy levels; however, their design was insufficient to determine if differences existed between any two groups (inadequate compared with adequate or marginal compared with adequate).[41,96]

Among individuals with diabetes, heart failure rates were higher in the limited health literacy group in one bivariate comparison.[69]

HIV infection severity and symptoms. Two adjusted and one unadjusted analysis of individuals with HIV consistently did not find differences by health literacy level in severity of HIV infection or symptoms measured as viral load suppression, CD4 cell counts, and number of HIV symptoms (Table 27).[67,77,85] However, higher health literacy was associated with greater symptom intensity in one study controlling only for Hispanic ethnicity.[82] In this study, health literacy was measured as a continuous variable among a population with relatively high health literacy (REALM mean score = 59.1). Overall, the strength of evidence was low (Table 8 and Appendix E). Our earlier review was limited to unadjusted analyses and found mixed results.

Asthma severity and control. The relationship between health literacy and asthma severity of children was examined in two studies reporting a mix of adjusted and unadjusted analyses (Table 28).[53,93] Overall, the strength of evidence was insufficient (Table 8 and Appendix E). Both studies measured asthma severity by parent report. In one, an adjusted analysis concluded that lower health literacy parents of children with asthma were more likely to report that their children were in fair or poor health; however, in an unadjusted comparison, these same parents' reports of their children's asthma control did not differ by health literacy level.[93] In a different unadjusted analysis, parents with lower health literacy reported greater use of albuterol (a bronchodilator) by their children, indicating poorer asthma control.[53] One adjusted analysis of asthma control in adults in our earlier review found that those with higher health literacy had better metered dose inhaler (MDI) technique.

Diabetes control, complications, and related outcomes. Four adjusted studies examined the relationship between glycosylated hemoglobin (HbA1c) level and health literacy level and found mixed results (Table 29).[69,79,91,97,107] One good-quality study conducted by Morris et al., measuring the HbA1c levels in 1,002 adults in Vermont found no relationship with health literacy level, measuring health literacy as a continuous variable using the TOFHLA, and controlling for demographic characteristics and several factors related to successful diabetes control such as duration, diabetes education, medication and alcohol use.[79] In contrast, a very small study (N = 68) from one general internal medicine clinic found significant differences in HbA1c between the four health literacy levels; each increasingly higher level of health literacy, however, was not associated with better control.[107] In a good quality study, using a path analysis statistical technique and controlling for potential confounders, Schillinger et al. found that higher health literacy was related to better glycemic control and that health literacy mediated the direct relationship between education and HbA1c level.[91] Also, higher health literacy diabetic patients in a Hong Kong study had better glycemic control.[97]

The large study of diabetic patients in Vermont, adjusting for confounders, did not find health literacy level to be related to blood pressure, cholesterol level, or the probability of having other potential side effects of poor diabetes control (retinopathy, nephropathy, foot or leg problems, gastroparesis, cerebrovascular disease, or coronary artery disease).[79]

The strength of evidence relating to diabetes outcomes from this review was low (Table 8 and Appendix E). In our earlier review, diabetes related results were mixed. Studies generally reported no significant difference by health literacy levels, adjusting for other confounding variables,

*Hypertension control***.** Two studies examined blood pressure control among patients diagnosed with hypertension; results were mixed (Table 30),[86,89] making the overall strength of evidence low (Table 8 and Appendix E). The larger study (N = 1,224), measuring health literacy using the REALM, did not find a relationship between systolic blood pressure and health literacy level (limited compared to adequate), controlling for confounders, including education level, diabetes status, medication adherence, smoking, exercise, and participatory decision-making.[89] A second analysis (N = 330), measuring health literacy using the S-TOFHLA subdivided into five categories and controlling for sociodemographic characteristics, education level, insurance status, number of comorbid conditions, and years treated for hypertension, found that those in the lowest category were less likely than those in the highest category to have controlled blood pressure (less than 140 mmHg systolic and less than 90 mmHg diastolic (or less than 130 mm Hg systolic and less than 80 mm Hg diastolic among those with diabetes) (RR, 2.68; 95% CI, 1.54-4.70).[86] In this study, the percentage of patients with controlled blood pressure was not consistently larger with every category of increasingly higher health literacy, and only some comparisons between various other health literacy level groups were significantly different. Our earlier review did not find a relationship between blood pressure control in hypertensive patients and health literacy level in an adjusted analysis from the one study reviewed with this outcome.

Prostate cancer control. Prostate cancer patients with low health literacy (sixth grade or less) were more likely than those with functional health literacy (ninth grade or higher) to have an elevated prostate-specific antigen (PSA) level in an adjusted good quality study (OR, 2.5; 95% CI, 1.5-4.2) (Table 31),[104] In contrast, the marginal literacy (seventh or eighth grade) group and the functional health literacy group did not differ. With only a single study, the strength of evidence was low (Table 8 and Appendix E). In our earlier review, stage of presentation of prostate cancer did not differ by health literacy level, in an adjusted analysis.

Global health status measures. Eleven studies reported in thirteen articles examined health status differences by health literacy level among a variety of populations, including all adults, seniors, and adults with various specific disease states (Table 32).[36,38,39,50,52,61,70,74,80,82,94,96,108] Health status was measured using an assortment of measures including self-report of overall health status (excellent/very good/good/fair/poor) and physical and mental health subscales of the SF-12 and SF-36, among others.

Only one study measured self-reported health status among all age adults (ages 18 to 85).[94] Limited to one clinic population in Canada, this work indicated that self-reported health status was not related to health literacy level, after adjustment for confounders. With only a single study, the strength of evidence was low (Table 8 and Appendix E).

In studies limited to senior citizens, four studies, reported in five articles, all found differences in self-reported health status by health literacy level,[36,50,52,70,96] the strength of evidence was moderate (Table 8 and Appendix E). Within a nationally representative sample (N = 2,668), after adjusting for potential confounders, one good study reported that lower health literacy level measured through the National Assessment of Adult Literacy (NAAL) was related to poorer self-reported health status.[50] Self-reported health status was also poorer in lower health literacy groups in two additional adjusted analyses: among Medicare patients in Chicago, Illinois,[52,70] and in the Prudential study comparing differences between the low and adequate literacy groups (but not marginal and adequate literacy groups).[36] The relationship was also found in one unadjusted analysis of 2,512 seniors in Pittsburgh, Pennsylvania, and Memphis, Tennessee.[96]

Two of the studies limited to seniors reported additional health status measures and results were mixed. Given mixed results, the strength of evidence was low (Table 8 and Appendix E). In adjusted analyses, the Prudential study found lower health literacy associated with poorer physical- and mental-health-related quality of life and physical functioning in both the inadequate and the marginal literacy groups (SF-36) compared with the adequate group.[36,38,39] In contrast, a sample of Medicare beneficiaries in Chicago, Illinois, was not found to differ in physical or mental functioning by health literacy level.[70] One of these two studies, the Prudential study, also found that persons with inadequate health literacy had higher probabilities of having activity limitations, fewer accomplishments, and greater pain related to physical health than those with adequate health literacy.[39]

Five studies examined differences in a variety of quality-of-life measures in adult populations with various diseases, including persons who were HIV-positive[82] and patients with glaucoma,[80] asthma,[74] spinal cord injuries,[108] and cancer.[61] No more than one study examined each disease state and results were mixed by disease state and quality of life outcome (e.g., general health, physical health, mental health, disease specific quality of life), thus, overall strength of evidence was graded as low (Table 8 and Appendix E). In HIV, better global physical health was related to lower health literacy.[82] In glaucoma, patients with lower health literacy had poorer physical, but not vision or mental, quality of life.[80] Among patients with spinal cord injuries, lower health literacy was associated with poorer physical morbidity, but not with mental health morbidity, physical health, or mental health status.[108] In cancer patients of all types, Functional Assessment of Cancer Therapy scores (related to physical and emotional functioning) and general health scores measured by the SF-36 showed no difference by health literacy level.[61] In asthma patients, lower health literacy was associated with poorer asthma quality of life and physical health status, adjusting for asthma severity and asthma self-sufficiency.[74] However, the relationship with both asthma outcomes was no longer significant after the investigators added age, education,

depressive symptoms, and knowledge confounders to their analyses. In our earlier review results of studies of global health measures, results were also mixed.

Mortality. Differences in all-cause mortality rates of seniors were related to health literacy in adjusted analyses in two good studies reported in three articles (Table 33).[38,40,95] The strength of evidence was graded as high (Table 8 and Appendix E). The Prudential study reported higher mortality rates in the inadequate health literacy group than in the adequate health literacy group—first in an analysis controlling for cognitive functioning[40] and second in an analysis not controlling for cognitive functioning but instead controlling for baseline measures of disease, physical functioning, and healthy lifestyle.[38] Both analyses did not find significant differences between the marginal and the adequate health literacy groups. In a population of seniors in Pittsburgh, Pennsylvania, and Memphis, Tennessee, those with limited health literacy had a higher all cause mortality rate than those with adequate health literacy.[95] The Prudential study also reported in adjusted analyses, higher cardiovascular related mortality in the inadequate and marginal health literacy groups than in the adequate group but no differences in cancer related mortality across health literacy levels.[38]

Summary of Outcomes and Strength of Evidence on Health Outcomes

The effect of health literacy on health outcomes was variable (Table 8). The risk of mortality for seniors was clearly higher with lower health literacy. The strength of evidence to support this finding was high. There was also a moderate strength of evidence to support a relationship between lower health literacy and poorer ability to interpret labels and health messages, higher mental health prevalence and related outcomes, and poorer overall health status among seniors. In these studies, the evidence consists of all observational studies, generally having a medium risk of bias and results generally in a consistent direction. The strength of evidence for all other outcomes was either low or insufficient because the literature consisted of a small number of studies, poorly designed studies, and/or inconsistent results. Strength of evidence evaluations focused on the relationship between the lowest health literacy group and the highest. The evidence was sparse for evaluating differences between those with marginal (a middle category) health literacy and adequate (the highest category).

KQ 1c. Costs of Health Care

KQ 1c concerns differences in health literacy level and costs of health care (Table 34) and had an overall low strength of evidence (Table 9 and Appendix E). The Prudential study of new Medicare managed care enrollees examined costs over a 1-year period. In adjusted analyses, inadequate and marginal health literacy groups had higher ED costs; however, no other patterns of differences were uncovered in relation to overall, inpatient, outpatient, or pharmacy costs.[41] In contrast, total Medicaid costs were higher in the lower literacy group (less than third grade) among a small sample of beneficiaries in Arizona (N = 74).[102] Our earlier review found no relationship between literacy and Medicaid costs.

Table 9. KQ 1 health literacy studies: strength of evidence grades by costs of health care

Outcome for Health Literacy Studies	Number of Studies	Results	Strength of Evidence Grade
Costs of health care	2	Mixed results across payment source and patient populations	Low

In summary, the strength of evidence concerning differences by health literacy level in costs of health care (KQ 1c) was low (Table 9). The two relevant studies examined different payment sources (Medicaid and Medicare), found inconsistent results, and included different patient populations. No studies examined differences in costs among those with private health insurance coverage or no coverage.

KQ 1d. Disparities in Health Outcomes or Health Care Service Use

Five studies examined whether health literacy is a mediator of the relationship between race/ethnicity and health outcomes or use of health care services and one study examined whether health literacy moderates the effect between race/ethnicity and health outcomes (Table 35). In these analyses, health literacy level was determined to be a mediator of the effect of race or ethnicity on an outcome when the coefficient for the race or ethnicity variable was smaller after health literacy was added to the analytic model. This mediator effect was found in adjusted analyses comparing black and white respondents in relation to a variety of outcomes: a national sample of adults included in the NALS in relation to a condition that keeps you from work and having a long term illness,[92] seniors included in the NAAL study in relation to self-reported health status and receipt of an influenza vaccine,[50] seniors included in the Prudential study in relation to physical and mental HRQoL and self reported health.[36] PSA levels among newly diagnosed prostate patients in Chicago,[104] HIV patients in relation to non-adherence to HIV medications.[42] The relationship was not found in relation to receipt of a mammogram or a dental checkup in the NAAL study[50] or rate of receipt of vaccines in the Prudential study.[36] Only the NAAL study examined whether health literacy mediated the effect of disparities between Hispanic and white respondents and this relationship was not found.[50] Health literacy was determined to be a moderator of the relationship between race/ethnicity and health outcomes when the relationship was different in magnitude or direction between the two groups. Only one study examined moderation and found that no relationship between mortality and health literacy level in blacks and whites.[95] The strength of evidence was moderate in relation to health literacy level being a moderator of differences in health outcomes between those of black and white race (Table 10 and Appendix E). The strength of evidence was low in relation to health literacy level being a moderator of differences in health outcomes between those of Hispanic ethnicity and white race (Table 10 and Appendix E). Data were not available to examine disparities related to cultural or age group differences. In our earlier review, little data was available to examine this issue.[2]

Table 10. KQ 1 health literacy studies: strength of evidence grades by disparities across health outcomes

Outcome for Health Literacy Studies	Number of Studies	Results	Strength of Evidence Grade
Disparities across health outcomes	6	Literacy mediates disparities in specific health outcomes between black and white race.	Black vs. white: Moderate
		Literacy not found to mediate the relationship between Hispanic and white race but little data available.	Hispanic: Low

In summary, health literacy mediates disparities in health outcomes between white and black participants for a variety of outcomes; strength of evidence for this conclusion is moderate (Table 10). Outcomes studied included a condition that keeps you from work or having a long term illness, self-reported health status, receipt of an influenza vaccine among seniors, physical and mental health-related quality of life, self reported health among seniors, prostate-specific antigen levels among newly diagnosed prostate cancer patients, and nonadherence to HIV medications. We cannot know whether health literacy level would also be a mediator of disparities between white and black race for other health outcomes that have not been tested. Only one study examined whether health literacy level mediated the relationship between race and health outcomes for persons of Hispanic ethnicity and white race. The strength of evidence for this relationship was low. We found no studies that evaluated disparities related to differences in age, sex, cultural group, or other sociodemographic characteristics.

Key Question 1: Relationship of Numeracy to Various Outcomes and Disparities

We identified 13 unique studies of the relationship between numeracy and outcomes of interest (Table 11). Nearly all studies examining the relationship of numeracy to health outcomes were cross-sectional in design.[8,23,62,65,106,116-122] Four studies were randomized controlled trials (RCTs) that analyzed their data in a cross-sectional manner for this analysis;[23,62,116,117] and one used a prospective cohort design.[54] All studies were of fair quality.

Table 11. Overview of numeracy studies

Source Design Quality Score	Population	Population Numeracy Levels	Outcomes	Potential Confounders Adjusted for in Analysis	Also examined literacy
Aggarwal et al., 2007[122] Cross-sectional Fair	264 patients at 4 ambulatory care clinics affiliated with an urban academic medical center in the US	74% Inadequate Numeracy on 5-item numeracy test adapted from Black and Toteson	• Knowledge • Healthcare Services	• Age • Race • Education • Primary care provider • FH disease	No
Cavanaugh et al., 2008[118] Cross-sectional Fair	398 patients from 2 primary care clinics and 2 endocrinology clinics at 3 hospitals in the US	69% < 9th grade WRAT-3, numeracy Diabetes Numeracy Test: Quartile 1: 27% Quartile 2: 25% Quartile 3: 26% Quartile 4: 23%	• Knowledge, • Self-Efficacy • Behavior • Disease prevalence/ severity	• None	Yes
Davids et al., 2004[119] Cross-sectional Fair	254 patients in 2 academic general medicine clinics in the US	% correct on numeracy test adapted from Schwartz and Woloshin: 0: 15% 1: 17% 2: 27% 3: 41%	• Accuracy of Risk Perception	• Age • Race • Education • Income • FH breast cancer • Age at menses • Age at first live birth • # of breast biopsies	No
Estrada et al., 2004[54] Prospective Cohort Fair	143 patients in anticoagulation management clinics in 1 university and 1 VA-based hospital in US	6-items (including 3 adapted from Schwartz and Woloshin): 0 correct: 13.3% 1-2 correct: 35% 3-4 correct: 34.3% 5-6 correct: 17.5%	• Medication Skill	• Age	No
Haggstrom and Schapira, 2006[120] Cross-sectional Fair	207 patients in general medicine clinic at academic medical center in US	NR % with all correct on Schwartz and Woloshin numeracy test	• Accuracy of Risk Perception	• Age • Race • FH • Family income • Insurance • Education	No
Hibbard et al., 2007[62] RCT Relevant data analyzed cross-sectionally Fair	303 community dwelling adults in the US	43% Low Numeracy (less than mean = 9 on 15-item scale adapted from Lipkus)	• Skill • Use of Healthcare Services	• None	Yes

HS, high school; NOS, not otherwise specified; NR, not reported; RCT, randomized controlled trial; TOFHLA, Test of Functional Health Literacy in Adults; US, United States; VA-based hospital, Veterans Administration-based hospital; WRAT-3, Wide Range Achievement-3rd edition.

Table 11. Overview of numeracy studies (continued)

Source Design Quality Score	Population	Population Numeracy Levels	Outcomes	Potential Confounders Adjusted for in Analysis	Also examined literacy
Huizinga et al., 2008[65] Cross-sectional Fair	169 patients in an academic primary care clinic in the US	66% < 9th grade WRAT-3, numeracy	• Disease Prevalence/severity	• Age • Gender • Race • Income • Education • REALM	Yes
Rothman et al., 2006[8] Cross-sectional Fair	200 patients at one academic primary care clinic in the US	63% < HS on WRAT-3, numeracy	• Skill • Disease prevalence/severity	• None	Yes
Schwartz et al., 1997[23] RCT Relevant data analyzed cross-sectionally Fair	287 patients at a Veterans hospital in the US who received a mailed survey	% correct on numeracy test from Schwartz and Woloshin 0: 30% 1: 28% 2: 26% 3 : 16%	• Accuracy of Risk Perception	• Age • Income • Education • Frame of Information	No
Sheridan and Pignone, 2002[116] RCT Relevant data analyzed cross-sectionally Fair	62 medical students in one US medical school	% correct on numeracy test from Schwartz and Woloshin 0-1: 5% 2: 18% 3: 77%	• Accuracy of Risk Perception	• None	No
Sheridan et al., 2003[117] RCT Relevant data analyzed cross-sectionally Fair	357 patients in an academic general medicine clinic in the US	% correct on numeracy test from Schwartz and Woloshin 0: 41% 1: 30% 2: 27% 3: 2%	• Accuracy of Risk Perception	• None	No
Vavrus, 2006[121] Cross-sectional Fair	277 students from four school districts in the United Republic of Tanzania	57% Low Numeracy (correctly completed 0-1 of 3 calculations on numeracy test NOS)	• Knowledge	• Gender • Literacy • Household spending • Parents education • Television in home • Siblings • Electricity • Sewage	No

Table 11. Overview of numeracy studies (continued)

Source Design Quality Score	Population	Population Numeracy Levels	Outcomes	Potential Confounders Adjusted for in Analysis	Also examined literacy
Yin et al., 2007[106] Cross-sectional Fair	292 caregivers of young children at the pediatric emergency department in an urban academic medical center in the US	NR by TOFHLA, numeracy (split at median)	• Knowledge, • Medication Skill	• Caregiver Education • Country of origin • Language • SES; Age of children • Regular healthcare provider • Experience in healthcare setting	No

Studies employed a wide variety of numeracy measures. These included the Wide Range Achievement Test (WRAT)-3, the Lipkus numeracy test, the Schwartz and Woloshin numeracy test (or adaptations thereof), the Diabetes Numeracy Test, the Black and Toteson Numeracy test (or adaptations thereof), and the TOFHLA numeracy test. Using these measures, populations studied had a varying proportion of individuals with low numeracy (ranging from 5 percent to 74 percent).

Studies also examined a wide variety of outcome measures. Among them were the accuracy of risk perception, knowledge, self-efficacy, actual behaviors, skills, disease prevalence and severity, and the use of health care services. No studies measured intent for behavior, adherence, quality of life, medical visits, or costs.

Four studies measured both literacy and numeracy.[8,62,65,118] This allowed assessment of whether these exposures affect health outcomes differently.

KQ 1a. Use of Health Care Services

Two studies (one cross-sectional study[122] and one RCT analyzing data in cross-sectional fashion[62]) examined the effect of numeracy on use of health care services (Table 36). One[122] focused on the effects of numeracy on use of screening services, the other[62] on choice of health care plans.

Screening services. In adjusted analyses, Aggarwal and colleagues reported no effect of numeracy level on up-to-date screening for either breast and colon cancer in women presenting for primary care.[122] However, the sample for colon cancer screening was small (N = 152; 58 percent of the total sample due to age ineligibility for screening for colon, but not breast cancer) and the authors provided no power calculations for either analysis.

Health plan choice. In an unadjusted analysis, Hibbard and colleagues reported fewer participants choosing a higher quality hospital (which we considered a proxy for health plan use) among those with lower numeracy (i.e. those scoring less than the mean on the Lipkus numeracy test).[62] This result was moderated by patient activation; subjects who were more motivated to process information were also more likely to make higher quality choices, regardless of their numeracy level.

Summary. In summary, only two studies addressed the relationship between numeracy and use of health care services and found mixed results, likely due in part to high risk of bias

with lack of adjustment for relevant confounders in one study and inadequate power in the other. Based on these studies, our research team judged the strength of the evidence for the relationship between numeracy and use of health care services to be insufficient (Table 12 and Appendix E).

Table 12. KQ 1 numeracy studies: strength of evidence grades by use of health care services outcomes

Outcome for Numeracy Studies	Number of Studies	Results	Strength of Evidence Grade
Use of health care services	2	Mixed results, no adjustment for confounding	Insufficient

KQ 1b. Health Outcomes

Accuracy of risk perception. Five studies addressed the effects of numeracy level on accuracy of risk perception (i.e., whether individuals correctly perceived their health risks and treatment benefits) (Table 37). Three were RCTs[23,116,117] and two were cross-sectional studies,[120] although all analyzed their data in cross-sectional fashion to answer this question. Two examined the effects of numeracy on the accuracy of perceived risk[119,120] and four on the accuracy of perceived treatment benefit.[23,116,117,120] All used the Schwarz and Woloshin 3-item numeracy test to assess numeracy.

The two studies examining perceived risk found no effect of numeracy level on the accuracy of perceived risk of breast cancer or breast cancer survival over 5 years.[119,120] One study, however, reported that for every additional numeracy question answered incorrectly (scale range 0-3), participants' error in estimating lifetime risk increased by 18 percent (95% CI, 5-30%).[119]

Four studies examined the effect of numeracy on the accuracy of perceived treatment benefit and found mixed results. Three studies reported lower accuracy of perceived treatment benefit at lower levels of numeracy (0-1 questions correct vs. 3 questions correct).[23,116,117] Notably, the size of the effect was smaller in the one study that adjusted for covariates including age, income, education, and the framing of information about treatment benefit (e.g., relative risk reduction or absolute risk reduction).[23] The fourth study, which also performed adjusted analysis, reported no significant difference between groups,[120] but the authors dichotomized their numeracy exposure variable differently (0-2 correct vs. 3 of 3 questions correct).

Interestingly, results varied across studies by how the investigators assessed accuracy. The differences in accuracy of perceived treatment benefit were greater between low and high numeracy participants who were asked to calculate an exact treatment benefit than between those who were asked merely to say which of two treatments provided more benefit.[116,117]

Considering all of these studies in aggregate, our research team judged the overall strength of evidence about the relationship between numeracy and accuracy of risk perception to be low due to mixed results by task and study (Table 13 and Appendix E).

Table 13. KQ 1 numeracy studies: strength of evidence grades by health outcomes

Outcome for Numeracy Studies	Number of Studies	Results	Strength of Evidence Grade
Accuracy of risk perception	5	Perceived risk (n = 2): mixed results depending on length over which risk estimated Perceived treatment benefit (n = 4): mixed results depending on cut-off for numeracy; 3 of 4 studies suggested low numeracy reduced accuracy of perceived benefit	Low
Knowledge	4	Mixed results, partially dependent on type of knowledge, sample size, and adjustment for confounding	Low
Self-efficacy	1	Lower self-efficacy in unadjusted analysis	Insufficient
Behavior	1	No relationship with self-care behavior in unadjusted analysis	Insufficient
Skills	4	Mixed results depending on type of skill Skill in taking medication (n = 2): mixed results Skill in interpreting health information (n = 2): Lower numeracy associated with lower comprehension	Skill in taking medication: Low Skill in interpreting health information: Low
Disease prevalence and severity	3	BMI (n = 2), HgbA1c (n = 1), illness requiring dietary restriction (n = 1): Mixed results	Low

BMI, body mass index; HbA1c, glycosylated hemoglobin; n, number.

Knowledge. We found four cross-sectional studies addressing the effect of numeracy level on knowledge (Table 38).[106,118,121,122] These focused on different types of knowledge as well as different health topics and conditions, including diabetes,[118] general health and HIV,[121] breast and colorectal cancer screening guidelines,[122] and medication dosing.[106] Results were mixed.

Three studies[118,121,122] including two that adjusted for relevant covariates[121,122] showed significantly lower knowledge about diabetes, HIV, and breast cancer screening with lower numeracy. These same studies, however, showed no effect of numeracy on general health knowledge or colorectal cancer screening, although nearly one-half of the sample queried about colorectal cancer screening included individuals who were too young to be eligible for screening. A fourth study showed lower numeracy is related to lower knowledge about medication dosing in an analysis controlling for some confounders;[106] however, results became non-significant after additional adjustment for education, acculturation, and socioeconomic status.

Considering these studies in aggregate, our research team judged the overall strength of evidence regarding the relationship between numeracy and knowledge to be low (Table 13 and Appendix E).

Self-efficacy. One cross-sectional study examined the effects of numeracy level on self-efficacy (Table 39).[118] In an unadjusted analysis, this study found significant reductions in self-efficacy (a 4 point reduction on the Perceived Diabetes Self-management scale ranging from 8 to 40) among those who scored in the lowest versus the highest quartile of the Diabetes Numeracy Test. Based on this single unadjusted analysis, the overall strength of evidence about the relationship between numeracy and self-efficacy was insufficient (Table 13 and Appendix E).

Intent for behavior. We found no studies that examined the effect of numeracy on intent for behavior.

Behavior. One cross-sectional study examined the effects of numeracy level on behavior (Table 40).[118] In unadjusted analysis, this study found no significant differences in diabetes self-management behaviors in 4 of 5 domains of the Diabetes Self-Care Activities Scale, including general diet behavior, specific diet behavior, exercise behavior, or blood glucose testing. However, there were small increases in foot care behavior (+2.25 on a scale of 0-7, $P < 0.001$) among those in the lowest versus highest quartile of numeracy; these unexpected results (as well as the negative results for analyses of other self-care behaviors) may be the result of confounding. Based on this single unadjusted analysis, our research team judged the overall strength of evidence about the relationship between numeracy and self-efficacy to be insufficient (Table 13 and Appendix E).

Health-related skills. Four studies examined the effects of numeracy level on health-related skills (Table 41). One was a cohort study,[54] two were cross-sectional studies,[8,106] and one was an RCT that analyzed data in cross-sectional fashion.[62] The skills included skills in taking medication, reading nutrition labels, and assessing health plan materials.

The two studies that focused on skills in taking medication found mixed results. In analyses adjusted for age, one found mixed effects of numeracy on two different, but related variables denoting medication-taking skill: the proportion of INR tests within range (adjusted absolute difference NR; $P = 0.35$) and INR variability (adjusted absolute difference NR; $P = 0.03$).[54] In an analysis adjusting for some identified confounders, the other study reported that poor caregiver numeracy resulted in use of non-standardized dosing instruments for administering medications to children.[106] Additional adjustment for education, acculturation, and socioeconomic status, however, led to non-significant differences between groups, based on TOFHLA numeracy scores split at the median. Based on these two studies, our research team judged the overall strength of evidence regarding the relationship between numeracy and skills in taking medication to be low (Table 13 and Appendix E).

The studies assessing other outcomes—skill at reading nutrition labels[8] and at reviewing health plan materials[62]—found lower comprehension of reviewed materials in those with lower numeracy. However, only the nutrition label study adjusted for potential confounders. Based on these studies, our research team judged the overall strength of evidence regarding the relationship between numeracy and skill in interpreting health information as low (Table 13 and Appendix E).

Disease prevalence and severity. Three cross-sectional studies examined the effect of numeracy level on disease prevalence and severity (Table 42).[8,65,118] These studies addressed the effects of numeracy on BMI[8,65] HbA1c[118] and illness requiring dietary restriction.[8]

The two studies addressing the effect of numeracy (measured by the WRAT-3 numeracy test) on BMI found mixed results in patients drawn from the same academic medicine practice. In one study, those scoring below the ninth grade level on the WRAT-3 had higher mean BMIs (adjusted beta coefficient, 0.14; $P = 0.01$).[65] By contrast, the other study reported no effect of

differential WRAT-3 scores on obesity (BMI >30) in unadjusted analysis.[8] The differences in findings may be attributable to a combination of differences in recruiting (physician referral in Huizinga study), handling of the outcome variable (continuous in the Huizinga study, categorical in Rothman study), and adjustment in analysis (adjusted in Huizinga study, unadjusted in Rothman study).

Findings on other health outcomes were also mixed. Cavanaugh and colleagues reported modest effects of numeracy on HgbA1c (adjusted beta coefficient: 0.09 for every 10 percentage point decrease in the proportion of correct responses on the Diabetes Numeracy Test).[118] Rothman and colleagues, however, reported no effects of numeracy on the proportion of individuals with illness requiring diet restriction in unadjusted analysis.[8]

Given the mixed nature of results, our research team judged the overall strength of evidence regarding the relationship between numeracy and disease prevalence to be low (Table 13 and Appendix E).

Summary. In summary, studies of the relationship between numeracy skill level and many health outcomes (including accuracy of risk perception, knowledge, skills taking medication, and disease prevalence and severity) found mixed results. Based on these findings, we judged overall strength of evidence for its relationship to these outcomes to be low. Close examination of the literature, however, suggests that lower numeracy level may lead to lower accuracy of perceived risk and treatment benefit, particularly if risk is presented over longer time frames (e.g., lifetime risks rather than 5-year risk) and if results reflect comparisons between those at the extremes of numeracy skill. Furthermore, evidence is emerging of a possible relationship between disease-specific knowledge, such that those with lower numeracy levels have less knowledge of their disease. One dissenting study among relatively few studies, however, overall precludes confidence in this conclusion.

The relationship between numeracy skill level and other outcomes is also uncertain. Two studies suggest a possible relationship between numeracy skill level and label reading skill, although only one adjusted for relevant confounders. Additionally, only one study each addressed the relationships between numeracy and self-efficacy and behavior (both with unadjusted analyses), making conclusions impossible.

KQ 1c. Costs

We found no study that examined the effect of numeracy on costs.

KQ 1d. Potential Mediator of Disparities

We found no study that directly addressed the effects of numeracy as a potential mediator or moderator of disparities in use of services or outcomes.

Table 14. Emergency department and hospitalization rates

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Baker et al., 2004[35] Cohort N = 3260 Good	Enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 24.5% Marginal: 11.2% Adequate: 64.2%	• Age • Gender • Race • Physical and Mental health • Chronic-diseases • Smoking • Alcohol use • BMI • Study site • Months enrolled	Any ED Visits Inadequate: 30.4% Marginal: 27.6% Adequate: 21.8% 1 ED visit: Inadequate: 17.0% Marginal: 15.3% Adequate: 15.0% 2 or more ED visits: Inadequate: 13.4% Marginal: 12.3% Adequate: 6.8%	Higher rate in inadequate or marginal compared with adequate Any ED Visit: Marginal: NR, (P = 0.01) Inadequate: NR, (P < 0.001) Higher rate in inadequate than adequate. No difference for marginal. 1 ED visit: Marginal: RR, 1.01; 95% CI, 0.76 to 1.33 Inadequate: RR, 1.07; 95% CI, 0.86 to 1.33 Higher rate in inadequate or marginal compared with adequate 2 or more ED visits: Marginal: RR, 1.44; 95% CI, 1.01 to 2.02 Inadequate: RR, 1.34; 95% CI, 1.00 to 1.79
Howard, et al., 2005[41] Cohort N = 3260 Good	New Medicare managed-care enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 24.5% Marginal: 11.2% Adequate: 64.2%	• Age • Sex • Race/Ethnicity • Income • Education • Tobacco • Alcohol • Comorbidities	Inpatient use Inadequate: 35% Marginal: 34% Adequate: 27% ED use Inadequate: 30% Marginal: 28% Adequate: 21%	Higher probability of inpatient and ED services in inadequate than adequate Mean differences in probability of inpatient use: 0.05; 95%CI, 0.00-0.09 ED: 0.05; 95%CI, 0.01-0.10 Mean differences in probability of marginal vs. adequate inpatient use: 0.04; 95%CI, -0.01-0.09 ED: 0.04; 95%CI, -0.01-0.09pharmacy: -0.04; 95%CI, -0.08-0.00

BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; ED, emergency department; HL, health literacy; IRR, incidence rate ratio; LVEF, left ventricular ejection fraction; N, number; NR, not reported; NYHA, New York Heart Association; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; RR, relative risk; Serum K, Serum K, serum potassium; S-TOFHLS, Short Test of Functional Health Literacy in Adults;

Table 14. Emergency department and hospitalization rates (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Hope et al., 2004[64] Cohort N = 61 Fair	Control group RCT participants with CHF in Indianapolis, Indiana Ability to read standard prescription Literacy level: NR Mean reading score: 1.65 ± 0.56	• Race • NYHA classification • Medications • Reading score	ED visits NR	Higher cardiovascular-related ED visits in patients with worse prescription label reading skills NR, (*P* = 0.002)
Murray et al., 2009[81] Cohort N = 192 Fair	University-based public clinic practice in Indianapolis Indiana S-TOFHLA Inadequate: 29.2% Adequate: 70.8%	• Age • Race • Insurance • NYHA class • LVEF • Hematocrit • CHF score • Serum Na, Income • Serum K, Cardiomyo-pathy questionnaire • Comparison Refill adherence Prescription label reading • Depression	ED Use Hospitalization NR	Adequate had a lower risk of hospitalization for heart failure than adequate All Cause ED visits (unadjusted): Prescription label reading score, 1 pt increment: IRR, 0.76; 95% CI, 0.59-0.97 Heat failure specific ED visits (unadjusted): Prescription label reading score: IRR, 0.36; 95%CI, 0.19-0.69 All cause hospitalization (unadjusted): Prescription label reading score: IRR, 0.68; 95% CI, 0.54-0.86 Heart failure specific hospitalization (unadjusted): IRR, 0.34; 95% CI, 0.15-0.76
DeWalt et al., 2007[53] Retrospective cohort N = 150 Fair	General, Asthma and Allergy, and Pulmonary clinic at Children's Hospital REALM Low: 24% High:76%	• Child age • Household income • Parental race • Parental asthma knowledge • Parental smoking • Asthma severity classification • Controller medication use • Site of care	ED Visits (per child): Inadequate: 1.53 Adequate: 1.08 Hospitalizations: Inadequate: 0.39 Adequate: 0.12	Children of parents with low HL had a greater incidence of ED visits than those with higher HL. IRR, 1.4, 95% CI, 0.97-2.0 Children of parents with low HL had a greater incidence of hospitalizations more than with higher HL IRR, 4.6, 95%, CI 1.8-12

Table 14. Emergency department and hospitalization rates (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Cho et al., 2008[52] Cross-sectional N = 489 Fair	Elderly outpatients at Hospital and an FQHC in Chicago S-TOFHLA Inadequate: 50.9% Adequate: 49.1%	• Race • Ethnicity • Gender • Educational attainment	ER Visits Hospitalizations Preventive care NR	More ER visits in lower HL group NR, (P < 0.05) More hospitalizations in lower HL group NR, (P < 0.05) Less preventive care in lower health literacy group NR, (P < 0.05)
Paasche-Orlow et al., 2005[83] Quasi-experimental/ pre-post N = 73 Fair	2 inner-city hospitals S-TOFHLA Inadequate: 22% Adequate: 78%	None	Hospital visit past 12 months Inadequate: 81% Adequate: 52% ED visit past 12 mo Inadequate: 88% Adequate: 75%	Inadequate HL associated with more hospitalization in past 12 mos. NR, (P = 0.04) (unadjusted) Inadequate HL not associated with ED visits in past 12 mos. NR, (P = 0.28) (unadjusted)
Shone et al., 2009[93] Cross-sectional N = 499 Fair	New York school district, where over 40% of children live in poverty REALM Low: 33% Adequate: 67%	• Ethnicity • Race • Child health Insurance • Parent employment	Used any urgent care: Low: 40.9% Adequate: 41.2%	Parent HL level not related to urgent care Used any urgent care: NR, (P > 0.999) (unadjusted)

Table 15. Colon cancer screening

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Miller et al., 2007[78] Cross-sectional N= 50 Fair	University community-based internal medicine clinic REALM Limited: 48% Adequate: 52%	• Age	Self-report of last time received colon screening Limited: 54% Adequate: 58%	No difference between limited and adequate groups. RR = 0.99; 95% CI, 0.64 -1.55
Cho et al., 2008[52] Cross-sectional N = 489 Fair	Elderly outpatients at Hospital and an FQHC in Chicago S-TOFHLA Inadequate:50.9% Adequate: 49.1%	• Race • Ethnicity • Gender • Education	FOBT: Data NR	Decreased probability in inadequate compared with adequate group NR, ($P < 0.05$)
Peterson et al., 2007[87] Cross-sectional N = 99 Fair	Community health clinic in Nashville, TN REALM Limited: 29.3% Adequate 70.7%	• Age • Sex • Race • Insurance	Up to date colon screening Inadequate: 51.7% Adequate : 65.7%	No difference between limited and adequate groups. OR, 0.67; 95% CI, 0.24-1.83
Guerra et al., 2005[59] Cross-sectional N = 136 Fair	4 Community Clinics, 2 University practices in Pennsylvania S-TOFHLA Inadequate:36% Marginal: 6% Adequate:58%	• Ethnicity • Medicaid • Education • Income	FOBT Inadequate/Marginal: 39% Adequate: 64% Sigmoidoscopy or Colonoscopy: Inadequate/Marginal: 30% Adequate: 72%	No differences between inadequate/marginal and adequate groups. FOBT: NR, ($P = 0.66$) Sigmoidoscopy or Colonoscopy NR, ($P = 0.52$)
White et al., 2008[103] Cross-sectional N = 18,100 Fair	Nationally representative US sample living in households NAAL Basic/below basic: 36% Intermediate:56% Proficient: 12%	• Age • Gender • Race • Poverty level • Insurance • Health status • Oral reading fluency	Colon cancer screen Below basic: 38% Basic: 41% Intermediate: 41% Proficient: 36%	Adults over 65 years: Decreased probability of having colon cancer screening basic/below basic groups. NR, ($P < 0.05$)

CI, confidence interval; FOBT, fecal occult blood test; FQHC, federally qualified health center; NR, not reported; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine; RR, relative risk; S-TOFHLA, short version of the test of functional health literacy adults; TN, Tennessee; US, United States.

Table 16. Pap tests

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Cho et al., 2008[52] Cross-sectional N = 489 Fair	Elderly outpatients at Hospital and an FQHC in Chicago S-TOFHLA Inadequate:51% Adequate: 49%	• Race • Ethnicity • Gender • Education	Pap: Data NR	Less pap screening in inadequate group than adequate group NR, ($P < 0.05$)
White et al., 2008[103] Cross-sectional NAAL N = 18,100 Fair	Nationally representative US sample living in households Basic or below basic: 36% Intermediate:56% Proficient: 12%	• Age • Race • Gender • Poverty level • Insurance • Health status, • Oral reading fluency	Pap test (age 18-65) Below basic: 63% Basic: 67% Intermediate: 70% Proficient: 74%	Adults under 40: Decreased probability of having a Pap test in basic/below basic than higher groups ($P < 0.05$) Adults 40-64: No differences by HL level NR, ($P > 0.05$)
Garbers et al., 2004[56] Cross-sectional N = 205 S-TOFHLA Fair	Women recruited through their younger female relatives in two women's health centers in New York City Inadequate: 30% Marginal: 19% Adequate: 51%	• Having a source of care • Having any health insurance • Age • Years in the US • Education	Ever had a Pap test Inadequate: 80% Adequate: 99% Marginal: 92.1% Pap test within past three years Inadequate: 62.3% Adequate: 82.9% Marginal: 82.1%	Less likely to ever have had a Pap test in inadequate compared to marginal and adequate Marginal: OR, 0.14; 95% CI, 0.01-1.41 Inadequate: OR, 0.06; 95% CI, 0.01-0.55 No differences in Pap test within past three years Marginal: OR, 1.31; 95% CI, 0.44-3.85 Inadequate: OR, 0.53; 95% CI, 0.21-1.35

CI, confidence interval; FQHC, federally qualified health center; HL, health literacy, S-TOFHLA, short version of the test of functional health literacy in adults; NAAL, national assessment o adult literacy; NR, not reported; OR, odds ratio; Pap, Papanicolau, US, United States.

Table 17. Mammography

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Bennett et al., 2009[50] Cross-sectional N = 2668 Good	Nationally sample of US population 65 and older NAAL Below Basic: 29.0% Basic: 29.5% Intermediate: 38.2 Proficient: 3.3%	• Age • Race • Gender • Income • Nativity	Mammography: Data NR	Lower utilization of mammography in the below basic/basic group: NR, ($P < 0.05$)
Cho et al., 2008[52] Cross-sectional N = 489 Fair	Outpatients at Hospital and an FQHC in Chicago S-TOFHLA Inadequate:50.9% Adequate: 49.1%	• Race • Ethnicity • Gender • Education	Mammography: Data NR	Less mammography in inadequate group than adequate group NR, ($P < 0.05$)
White et al., 2008[103] Cross-sectional N = 18,100 Fair	Nationally representative US sample living in households NAAL Basic or below basic: 36% Intermediate:56% Proficient: 12%	• Age, • Gender • Race • Poverty level • Insurance status • Self-reported health status, • Oral reading fluency	Mammogram (age >40) Below basic:58% Basic: 61% Intermediate:62% Proficient: 62%	Adults >65: Decreased probability mammography in below basic or basic group NR, ($P < 0.05$)
Guerra et al., 2005[60] Cross-sectional N = 97 Fair	3 community health clinics in Philadelphia S-TOFHLA Inadequate: 70% Adequate: 30%	• Age • Education • Acculturation • Insurance status	Mammogram: Data NR	Inadequate HL associated with only lower odds of ever having a mammogram Ever had a mammogram: OR, 0.88; 95% CI, 0.79-0.98 Had last mammogram within 1 yr: OR, 0.99; 95% CI, 0.92-1.05 Had last mammogram within 2 yrs: OR, 1.02; 95% CI, 0.93- 1.09 Had mammogram as part of check-up: OR, 0.99; 95% CI, 0.92-1.06

CI, confidence interval; FQHC, federally qualified health center; HL, health literacy; NAAL, national assessment of adult literacy; NR, not reported; OR, odds ratio; S-TOFHLA, short version of the test of functional health literacy in adults; US, United States; yr, year.

Table 18. Sexually transmitted infections testing

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Barragan et al., 2005[48] Cross-sectional N = 372 Fair	Inner city public hospital urgent care center, Atlanta, GA REALM Inadequate:25 % Adequate: 75%	• Age • Education	HIV Test Acceptance: Data NR	Inadequate HL positively associated with acceptance of HIV test compared with adequate group OR, 2.017; 95% CI, 1.190- 3.418

CI, confidence interval; GA, Georgia; HIV, human immunodeficiency virus; HL, health literacy; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine.

Table 19. Immunizations

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
White et al., 2008[103] Cross-sectional N = 18,100 Fair	Nationally representative US sample living in households NAAL Basic or below basic: 36% Intermediate: 56% Proficient: 12%	• Age • Gender • Race • Poverty level • Insurance • Health status, • Oral reading fluency	Pneumonia shot Below basic: 39% Basic: 42% Intermediate: 38% Proficient:27% Flu shot Below basic: 39% Basic: 37% Intermediate: 32% Proficient: 26%	Adults under 40: Increased probability of having a flu shot in basic/below basic group NR, ($P < 0.05$) Adults 40-64: NR, (P = NS) Adults >65: Decreased probability of flu shot. Not related to having a pneumonia shot. NR, ($P < 0.05$)
Howard et al., 2006[36] Cohort N = 3260 Fair	Prudential Medicare managed care plan in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 24.4% Marginal: 11.5% Adequate: 64.4%	• Age • Gender • Race/Ethnicity • Education • Income • Site • Morbidity • Smoker	Influenza vaccine: Data NR Pneumococcal vaccine: Data NR	Influenza vaccine receipt lower in inadequate than adequate. OR, 0.76; (P = 0.020) No differences in pneumococcal vaccine receipt between inadequate and adequate. OR, 0.85; (P = 0.114) No difference between marginal and adequate groups Influenza vaccine: OR, 1.06; (P = 0.707) Pneumococcal vaccine: OR, 0.91; (P = 0.445)

CI, confidence interval; NAAL, national assessment of adult literacy; NR, not reported; NS, not significant; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine; S-TOFHLA, short version of the test of functional health literacy in adults; US, United States.

Table 19. Immunizations (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Sudore et al., 2006[96] Cross-sectional N = 2,512 Fair	Well-functioning, Medicare recipients living in the community in Memphis and Pittsburgh REALM Limited: 24% Adequate: 76%	• Age • Race • Sex • Income • Study site • Health status • Cardiac disease • Stroke • Cancer • Hypertension • Diabetes • Obesity • Depressive symptoms	Influenza shot: Data NR	Inadequate less likely to have influenza shot in 12 months OR, 0.59; 95% CI, 0.41-0.83 Marginal less likely to have influenza shot in 12 months OR, 0.94; 95% CI, 0.7-1.25
Bennett et al., 2009[50] Cross-sectional N = 2668 Good	Nationally representative sample of US population 65 and older NAAL Below Basic: 29.0% Basic: 29.5% Intermediate: 38.2 Proficient: 3.3%	• Age • Race • Gender • Income • Nativity	Influenza vaccination: Data NR	Lower utilization of influenza vaccination in below basic and basic group: NR, ($P < 0.05$)

Table 20. Access to office visits and general care

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Baker et al., 2004[35] Cohort N = 3260 Good	Prudential Medicare managed care enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 24.5% Marginal: 11.2% Adequate: 64.2%	• Age • Gender • Race • Physical and Mental health • Chronic-diseases • Smoking • Alcohol use • BMI • Study site • Months enrolled	Number of physician visits: Inadequate: 9.8% Marginal: 9.3% Adequate: 8.1% Total physician visits Inadequate: 13.7 Marginal: 13.5 Adequate: 14.3 Mean physician visits Inadequate: 2.2 Marginal: 2.2 Adequate: 2.2	HL not associated with time to first physician visit, mean number of physician visits, or no physician visit in the first year. Number physician visits Marginal: OR,1.23; 95% CI, 0.82-1.85 Inadequate: OR, 1.23; 95% CI, 0.88-1.72 Time to first visit Marginal: HR, 0.89; 95% CI, 0.78 - 1.00 Inadequate: HR, 0.94; 95% CI, 0.84 to 1.04 Mean visits : Marginal: NR, (*P* = 0.34) Inadequate: NR, (*P* = 0.38) Mean visits: Marginal: NR, (*P* = 0.27) Inadequate: NR, (*P* = 0.62)

BMI, body mass index; CI, confidence interval; ED, emergency department; HIV, human immunodeficiency virus; HL, health literacy; HR, hazard ratio; mos, months; NAAL, national assessment of adult literacy; NR, not reported; NS, not significant; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine; sig, significant; S-TOFHLA, short version of the test of functional health literacy in adults; TOFHLA, test of functional health literacy in adults; US, United States; vs., versus.

Table 20. Access to office visits and general care (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Howard et al., 2005[41] Cohort N = 3260 Good	New Prudential Medicare managed-care enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 24.5% Marginal: 11.2% Adequate: 64.2%	• Age • Sex • Race/Ethnicity • Income • Education • Tobacco • Alcohol • Comorbidities	Overall use Inadequate: 95% Marginal: 96% Adequate: 97% Inpatient use Inadequate: 35% Marginal: 34% Adequate: 27% Outpatient use Inadequate: 90% Marginal: 90% Adequate: 91% ED use Inadequate: 30% Marginal: 28% Adequate: 21% Pharmacy use Inadequate: 85% Marginal: 85% Adequate: 88%	Inadequate HL not related to overall use, outpatient, or pharmacy use Marginal HL used more pharmacy services than those with adequate HL. All other use comparisons not sig Mean differences in probability of use Inadequate vs. adequate overall: 0.00; 95%CI, -0.02-0.02 outpatient: -0.02; 95%CI, -0.05-0.01 pharmacy: -0.03; 95%CI, -0.06-0.00 Mean differences in probability of use Marginal vs. adequate overall: 0.00; 95%CI, -0.02-0.03 outpatient: -0.01; 95%CI, -0.04-0.02 pharmacy: -0.04; 95%CI, -0.08-0.00
Lindau et al., 2006[73] Cohort N = 68 Fair	Clinics in Chicago area academic medical center REALM Inadequate: 35% Adequate: 65%	• Age • Race • HIV status • Cancer • Unemployment • Insurance	Patient followed up on time after abnormal Pap Inadequate: 33% Adequate: 66% Patient followed up within one year Inadequate: 67% Adequate: 80%	No differences on-time follow-up after an abnormal Pap smear between inadequate and adequate groups OR, 2.05; 95% CI, 0.47-8.85 No differences in predicting women's follow-up within one year between inadequate and adequate groups. OR, 3.75; 95% CI, 0.81-17.4
Grubbs et al., 2009[58] Retrospective cohort N = 62 Fair	5 San Francisco bay outpatient dialysis units S-TOFHLA Inadequate: 32.3%	• Race • Gender • Income • Age at start of dialysis • Support • Hypertension • Diabetes • Peripheral vascular disease	Time from dialysis date to transplant list referral date Inadequate: 23.5 mos Adequate: 15.3 mos Time from transplant	Longer time from dialysis date to transplant referral list date in inadequate group than adequate group HR 4.54; 95% CI, 1.67-12.5 No difference in time from transplant list referral date to

Table 20. Access to office visits and general care (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
Grubbs et al., 2009[58] (continued)	Adequate: 67.7%	• Coronary artery disease • HIV • Hepatitis C • Congestive heart failure • Depression • Drug abuse.	list referral date to waitlist date Inadequate: 6.6 mos Adequate: 2.1 mos	waitlist date by HL HR 1.25; 95% CI, 0.62- 3.45
Hibbard et al., 2007[62] Cross-sectional N = 303 Fair	Community TOFHLA (passage B) Low: 45% High: 55%	• Age • Gender • Education • Comprehension • Activation	Choosing a quality choice hospital NR	No differences in predicting quality choice of a hospital between inadequate and adequate groups. NR, (*P* = NS)
Sudore et al., 2006[96] Cross-sectional N = 2,512 Fair	Well-functioning, Medicare recipients living in the community with multiple sources of medical care in Memphis and Pittsburgh REALM Limited: 24% (= 8.8%, 0-6th grade, + 15.2%,marginal/7-8th grade): Adequate: 76%	• Age • Race • Sex • Income, • Study site • Health status • Cardiac disease • Stroke • Cancer • Hypertension • Diabetes • Obesity • Depressive symptoms	Doctor/clinic Insurance for meds Composite access measure: Data NR	Less access in 3 of 4 access measures between limited and adequate group. No doctor/clinic OR, 0.79; 95% CI, 0.43-1.45 No insurance for medication OR, 0.58; 95% CI, 0.41-0.81 Composite access measure OR, 0.51; 95% CI,, 0.35-0.75 Marginal group did not differ from adequate group in any access measures No doctor/clinic OR, 0.90; 95% CI, 0.54- 1.49 No insurance for medication: OR,.97; 95% CI, 0.75- 1.25 Composite access measure: OR, 1.05; 95% CI, 0.81- 1.35
Mancuso et al., 2006[74,75] Cross-sectional N = 175 Fair	Primary care practice in New York City TOFHLA Inadequate: 10% Marginal: 8% Adequate: 82%	• Age • Race/ethnicity • Sex • Comorbidity • Language • Asthma duration • Asthma severity • Asthma control	Access to asthma care Access to care due to other conditions Data NR	No difference by HL level More difficult to access asthma care: NR, (*P* = 0.58) More difficult access to medical care for other medical conditions: NR, (*P* = 0.005)

Table 20. Access to office visits and general care (continued)

Authors, Year. Study Design, Literacy tool, Sample Size, Quality	Population and Setting, Literacy category	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Skill Level	Differences in Results Between Health Literacy Skill Levels
White, et al., 2008[103] Cross-sectional N = 18,100 Fair	Nationally representative US sample living in households NAAL Basic or below basic: 36% Intermediate:56% Proficient: 12%	• Age, • Gender • Race • Poverty level • Insurance status • Self-reported health status, • Oral reading fluency	Dental checkup Below basic: 44% Basic: 59% Intermediate: 70% Proficient:77% Vision checkup Below basic: 54% Basic:58% Intermediate: 59% Proficient:58% Prostate screen Below basic: 31% Basic: 34% Intermediate: 31% Proficient: 26% Osteoporosis screen Below basic: 17% Basic:13% Intermediate: 11% Proficient:7%	Adults under 40: Decreased probability of having a vision check-up for below basic/basic HL. NR, ($P < 0.05$) No association with dental check-ups NR, NS Adults 40-64: Decreased probability of dental checkup for below basic/basic NR, ($P < 0.05$) Adults > 65: Decreased probability of dental check-up, vision check-up, osteoporosis screening and prostate cancer screening in below basic/basic HL group. NR, ($P < 0.05$) No differences by HL related to men's screening for osteoporosis NR, NS

Table 21. Summary of studies of the relationship between health literacy and the outcome of adherence (KQ 1b)

Authors, Year. Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Kalichman et al., 2008[67] Prospective cohort N = 145 Fair	HIV positive adults in Atlanta, Georgia TOFHLA Lower: 49% Higher: 51%	• Age • Education • Years since testing HIV positive • HIV symptoms • Depression • Internalized stigma • Social support • Alcohol use	Antiretroviral therapy pill adherence < 85% (pills counts averaged over past 4 months) Lower: 84% Higher: 69%	Antiretroviral therapy pill non-adherence greater in lower health literacy group (adjusted) (OR: 3.77; 95% CI, 1.46-9.93)
Osborn et al., 2007[42] (companions: Wolf et al., 2007;[43] Waite et al., 2008[44]) Cross-sectional N = 204 Fair	Patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana REALM Low: 11% Marginal: 20% Adequate: 69%	• Race • Gender • Age • Income • Number of medications in HIV regimen • Non-HIV comorbid conditions • Mental illness	Non-adherence to HIV medications in past 4 days (self report) Low: 52% Marginal: 19% Adequate: 30%	Non-adherence higher in low than adequate group (adjusted) (OR, 2.12, 95% CI, 1.93 - 2.32) No difference in non-adherence between marginal and adequate groups (adjusted) (OR, 1.55, 95% CI, 0.93 - 2.45)
Wolf et al., 2007[43] (companions: Osborn et al., 2007;[42] Waite et al., 2008[44]) Cross-sectional N = 204 Fair	Patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana REALM Low: 11% Marginal: 20% Adequate: 69%	• Mediator: HIV treatment knowledge • Mediator: HIV medication self-efficacy • Age • Insurance coverage • Employment status • Number of medications in HIV regimen • Number of non-HIV prescription medications currently taking • Presence of comorbid chronic conditions • Treatment for mental health condition past 6 months • Treatment alcohol or drug use past 6 months	Non-adherence to HIV medications in past 4 days (self report) Low: 52% Marginal: 19% Adequate: 30%	No difference in non-adherence between low and adequate groups (adjusted) (OR 0.8, 95% CI, 0.8-5.3) No difference in non-adherence between marginal and adequate groups (adjusted) (OR 1.6, 95% CI, 0.6-4.7)

CD4, cluster of differentiation 4; CI, confidence interval; HIV, Human immunodeficiency virus; HR, hazard ratio; N, number; NR, not reported; OR, odds ratio; REALM, Rapid estimate of adult literacy in medicine; S-TOFHLA, Short Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults.

Table 21. Summary of studies of the relationship between health literacy and the outcome of adherence (KQ 1b) (continued)

Authors, Year. Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Waite et al., 2008[44] (Companions: Osborn et al., 2007;[42] Wolf et al., 2007[43]) Cross-sectional N = 204 Fair	Patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana REALM Low: 11% Marginal: 20% Adequate: 69%	• Mediator: Stigma concerns related to HIV medications (self report) • Age • Gender • Site • Employment status • Number of medications in HIV regimen • Number of non-HIV prescription medications taken • Comorbid chronic condition • Treatment for mental health condition • Treatment for substance abuse	Non-adherence to HIV medications in past 4 days (self report) Low: 52% Marginal: 19% Adequate: 30%	Non-adherence is positively related to being in the low compared to the adequate group (adjusted-not controlling for stigma) (OR 3.3, 95% CI, 1.3-8.7) No difference in non-adherence between low and adequate group after stigma is added to the model (adjusted) (OR 2.1, 95% CI, 0.7-6.5) No difference in non-adherence between marginal and adequate group (adjusted-not controlling for stigma) (OR 2.1, 95% CI, 0.8-5.5) No difference in non-adherence between low and adequate group after stigma is added to the model (adjusted) (OR 0.7, 95% CI, 0.2-1.8)
Graham et al., 2007[57] Retrospective cohort N = 87 Fair	Patients at an HIV clinic in Philadelphia, Pennsylvania REALM: Low: 49% Adequate: 51%	• Mediator: Individual's norm for acceptable adherence	< 95% adherence to HIV medication regimen (self-report of pill counts over past 3 months) Low: 60% Adequate: 36%	No difference in non-adherence between low and adequate groups (adjusted) (OR: 0.36; 95% CI, 0.17-1.02)
Paasche-Orlow et al., 2006[85] Retrospective cohort N = 235 Fair	Patients with HIV and a history of alcohol problems in Boston, Massachusetts REALM: Low: 14% Marginal: 29% Adequate: 57%	• Gender • Age • Education • Randomization group • Ethnicity • Homeless status • Drank to intoxication past 30 days • Injected drugs past 6 months • Complexity of regimen	100% adherence to HIV medication regimen (self-report for 3 day period) Low: 69% Marginal: 63% Adequate: 64%	No difference in total adherence between low and adequate group (adjusted) (OR 1.93, 95% CI, 0.86-4.31) No difference in total adherence between marginal and adequate group (adjusted) (OR 1.29, 95% CI, 0.77-2.19)

Table 21. Summary of studies of the relationship between health literacy and the outcome of adherence (KQ 1b) (continued)

Authors, Year. Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Gazmararian et al., 2006[34] (companions: Wolf et al., 2007;[37] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Prospective cohort N = 1,549 Fair	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Inadequate: 24% Marginal: 12% Adequate: 64%	• Age • Race • Gender • Education • Regimen complexity	Non-adherence to cardiovascular medication refill adherence (one year period) Low: 45% Marginal: 42% Adequate: 38%	No difference in non-adherence between low and adequate groups (adjusted) (OR: 1.23; 95%CI, 0.92-1.64) No difference in non-adherence between low and adequate groups (adjusted) (OR: 1.15; 95%CI, 0.82-1.62)
Fang et al., 2006[55] Cross-sectional N = 179 Fair	Patients at anticoagulation clinic in San Francisco, California S-TOFHLA Limited: 61% Adequate: 39%	• Age • Sex • Race/ethnicity, • Education, • Cognitive impairment, • Years on warfarin	Adherence to medication as measured by self-report of missed doses over 3 time periods (last 3 days, last 2 weeks, > 3 months) No missed doses > past 3 months: Limited: 61% Adequate: 51%	No difference in adherence between groups by any of the measures of missed doses (adjusted) Did not miss a dose in > 3 months (adjusted) (OR, 0.9; 95% CI, 0.4 - 2.0)
Chew et al., 2004[51] Prospective cohort N = 332 Fair	Preoperative clinic of the VA Puget Sound Inadequate:4% Marginal: 8% Adequate: 88%	• Age • Marital status • Number of medications • Cognitive functioning	Non-adherence to fasting instructions Inadequate/Marginal: 9% Adequate: 8% Non-adherence to pre-operative medication instructions: Inadequate/Marginal: 37% Adequate: 21%	No difference between groups in non-adherence to fasting instructions (unadjusted) (P = 0.80) No difference between groups in non-adherence to pre-operative medication instructions (adjusted) (OR, 1.9; 95% CI, 0.8-4.8)

Table 21. Summary of studies of the relationship between health literacy and the outcome of adherence (KQ 1b) (continued)

Authors, Year. Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Hironaka et al., 2009[63] Prospective cohort N = 110 Fair	Caregivers of infants who receive care at 2 pediatric clinics S-TOFHLA Inadequate/Marginal: 18% Adequate: 82%	• Race/ethnicity • Caregiver education • Caregiver concerns regarding multivitamins and possible side effects • Randomized assignment to drops or sprinkle formulation	Caregivers' self-reported days of adherence to giving vitamins to their infants in prior week Inadequate/Marginal: 3.7 days Adequate: 2.4 days	Adherence positively related to being in the inadequate/marginal group compared to the adequate group (adjusted) (OR, 2.4; 95% CI, 1.37-4.2)
Cho et al., 2008[52] (companion: Lee et al., 2009[70] Cross-sectional N = 489 Fair	Seniors who are patients at 1 of 2 Chicago, Illinois clinics s-TOFHLA Inadequate/marginal: 51% adequate: 49%	• Race/ethnicity • Gender • Education	Non-adherence: failed to fill prescriptions on time (self report) Inadequate/marginal: NR Adequate: NR	Using path analysis, health literacy level did not have a significant direct effect on non-adherence (adjusted) ($\beta = -0.17$, $P \geq 0.05$)

Table 22. Summary of studies of the relationship between health literacy and the outcome of self-efficacy (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Wolf et al., 2007[43] (companions: Osborn et al., 2007;[42] Waite et al., 2008[44] Cross-sectional N = 204 Fair	Patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana REALM Low: 11% Marginal: 20% Adequate: 69%	• Age • Insurance coverage • Employment status • Number of medications in HIV regimen • Number of non-HIV prescription medications currently taking • Presence of comorbid chronic conditions • Treatment for mental health condition past 6 months • Treatment alcohol or drug use past 6 months	Perception of self-efficacy to properly take and manage HIV medication Low: 61% Marginal: 20% Adequate: 24%	Higher HIV medication self- efficacy greater in adequate than low group (adjusted) (OR 5.8; 95% CI, 2.0-15.7) No difference HIV medication self-efficacy between adequate and marginal groups (adjusted) (OR 1.6; 95% CI, 0.3-3.2)
von Wagner et al., 2009[100] Cross-sectional N = 96 Fair	Adults in London, England between 50-69 years of age UK-TOFHLA Mean: 92.2 Range: 26-100	• Age • Ethnicity • Employment • Gender • Number of computer links open • Mean reading time • CRC screening knowledge	Self-efficacy for participating in CRC screening Self-efficacy by health literacy level: NR	Higher health literacy level associated with greater self-efficacy (adjusted) (β = 0.061; 95% CI, 0.009-0.113
Torres et al., 2009[98] Cross sectional N = 106 Fair	Women patients at a family health center in New York City s-TOFHLA Inadequate: 46% Marginal: 18% Adequate: 36%	None	Self-efficacy for taking hormone therapy Self-efficacy by health literacy level: NR	Self efficacy positively correlated with health literacy level (unadjusted): r = 0.70 (P < 0.01)
Peterson et al., 2007[87] Cross-sectional N = 99 Fair	Patients with public health care coverage at a community health clinic in Nashville, Tennessee REALM Limited: 29% Adequate: 71%	• Age • Sex • Race • Insurance status	Mean perception of self-efficacy score FOBT Limited: 3.87 Adequate: 3.93 Colonoscopy: Limited: 3.92 Adequate: 3.99	No difference between groups in perception of self-efficacy for FOBT (adjusted) (P = 0.44) No difference between groups in perception of self-efficacy or colonoscopy (P = 0.52)

CRC, colorectal cancer screening; FOBT, fecal occult blood test; HIV, human immunodeficiency virus; N, number; REALM, Rapid Estimate of Adult Literacy in Medicine; UK-TOFHLA, Short Test of Functional Health Literacy in Adults, United Kingdom.

Table 23. Summary of studies of the relationship between health literacy and health behaviors (KQ1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
von Wagner, 2007[99] Cross-sectional N = 719 Fair	National sample of British adults Modified TOFHLA Inadequate: 6% Marginal: 6% Adequate: 89% Continuous measure used in analysis	• Age • Education • Gender • Ethnicity • Income	Don't smoke Inadequate: 29% Marginal: 32% Adequate: 70% Fruit and vegetable intake ≥ 5/day Inadequate: 29% Marginal 39% Adequate: 47% Any exercise in the last week: Inadequate: 22% Marginal: 20% Adequate: 36.6%	Higher HL associated with greater likelihood of not smoking (adjusted) (OR, 1.02; 95% CI, 1.003-1.03) Higher HL associated with greater likelihood of eating ≥ 5 fruit/vegetables a day (adjusted) (OR, 1.02; 95% CI, 1.003-1.03) HL level not associated with likelihood of having exercised in the last week (adjusted) (OR, 1.00; 95% CI, 0.98-1.02)
Wolf, 2007[37] (companions: Gazmararian, 2006;[34] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Cross-sectional N = 2,923 Fair	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Inadequate: 22% Marginal: 11% Adequate: 66%	• Age • Gender • Race/ethnicity • Language (English or Spanish) • Site • Education • Annual income • Occupation (white or blue collar)	Smoking (never): Inadequate: 47% Marginal: 42% Adequate: 39% Smoking (former) Inadequate: 42% Marginal: 45% Adequate: 49% Smoking (current) Inadequate: 12% Marginal: 13% Adequate: 12% Current alcohol use (none) Inadequate: 75.6% Marginal: 64.2% None: 57.9% Current alcohol use (light to moderate) Inadequate: 23% Marginal: 34% Adequate: 38% Current alcohol use (heavy) Inadequate: 2% Marginal: 2% Adequate: 4%	Difference in smoking status (adjusted) No difference between groups in ever versus never smoking. Inadequate versus adequate (OR: 0.9; 95%CI, 0.7-1.1) Marginal versus adequate (OR: 0.9; 95%CI, 0.7-1.2) No difference between groups in ever versus quit smoking. Inadequate versus adequate (OR: 0.9; 95%CI, 0.6-1.3) Marginal versus adequate (OR: 0.7; 95%CI, 0.5-1.0) Difference in alcohol consumption (adjusted)

BMI, Body Mass Index; CI, confidence interval; HL, health literacy; HIV, Human immunodeficiency virus; INR, International Normalized Ratio; N, number; NR, not reported; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine; RR, risk ratio; TOFHLA, Test of Functional Health Literacy in Adults; S-TOFHLA, short form Test of Functional Health Literacy in Adults.

Table 23. Summary of studies of the relationship between health literacy and health behaviors (KQ1b) **(continued)**

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Wolf, 2007[37] (companions: Gazmararian, 2006;[34] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) (continued)			Physical Activity per week (< 1 time) Inadequate: 38% Marginal: 25% Adequate: 22% Physical Activity per week (1-2 times) Inadequate: 15% Marginal: 16% Adequate: 15% Physical Activity per week (3 times) Inadequate: 14% Marginal: 18% Adequate: 15% Physical Activity per week (> 4 times) Inadequate: 33% Marginal: 41% Adequate: 48% Seat belt use (always) Inadequate: 72% Marginal: 78% Adequate: 78% Seat belt use (nearly always, sometimes, or seldom) Inadequate: 28% Marginal: 22% Adequate: 22%	No difference between groups in light/moderate versus no alcohol consumption Inadequate versus adequate (OR: 1.1; 95%CI, 0.5-2.5) Marginal versus adequate (OR: 1.4; 95%CI, 0.6-3.3) No difference between groups in heavy versus no alcohol consumption Inadequate versus adequate (OR: 1.3; 95%CI, 0.6-3.0) Marginal versus adequate (OR: 1.2; 95%CI, 0.5-2.8) Difference in physical activity (adjusted) No difference between groups in physical activity 1-2 times per week versus less than 1 time Inadequate versus adequate (OR: 1.0; 95%CI, 0.7-1.4) Marginal versus adequate (OR: 1.3; 95%CI, 0.9-1.8) No difference between groups in physical activity 3 times per week versus less than 1 time

Table 23. Summary of studies of the relationship between health literacy and health behaviors (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Wolf, 2007[37] (companions: Gazmararian, 2006;[34] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) (continued)				Inadequate versus adequate (OR: 0.9; 95%CI, 0.7-1.3) Marginal versus adequate (OR: 1.0; 95%CI, 0.7-1.5) No difference between groups in physical activity greater than 4 times per week versus less than 1 time Inadequate versus adequate (OR: 1.3; 95%CI, 0.9-1.7) Marginal versus adequate (OR: 1.0; 95%CI, 0.7-1.4) No difference between groups in seat belt use (unadjusted) (P = 0.13)
Baker et al., 2007[38] (companions: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Howard et al., 2005;[41] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Cohort N = 3,260 Good	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Inadequate: 24% Marginal: 11% Adequate: 64%	None	BMI < 18.5 Inadequate: 8% Marginal: 4% Adequate: 4% BMI 18.5-24.9 Inadequate: 59% Marginal: 60% Adequate: 58% BMI 25.0-29.9 Inadequate: 23% Marginal: 24% Adequate: 26% BMI > 30.0 Inadequate: 10% Marginal: 12% Adequate: 12%	Difference in BMI across groups (unadjusted) (P < 0.005)

Table 23. Summary of studies of the relationship between health literacy and health behaviors (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Huizinga et al. 2008[65] Cross-sectional N = 160 Fair	Patients at primary care clinic at Vanderbilt University REALM < 9th grade: 23% ≥ 9th grade: 77%	None	BMI < 9th: 31.7 (SD 9.9) ≥ 9th : 30.2 (SD 7.8)	No difference between groups in BMI level (unadjusted) (*P* = 0.50)
Sudore, 2006[96] (companion: Sudore et al., 2006[95]) Cross-sectional N = 2,512 Fair	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM 0-6th grade: 8% 7-8th grade: 15% ≥9th grade: 76%	None	Obesity (BMI > 30) 0-6th grade: 29% 7th-8th grade: 32% ≥ 9th grade: 23%	Difference in probability of obesity across groups (unadjusted) (OR: 1.51, 95% CI: 1.23, 1.85)
Rothman, 2006[8] Cross-sectional N = 200 Fair	Adults in a primary care clinic REALM < HS: 23% ≥ HS: 77%	None	Obese (BMI ≥ 30): < HS: 53% ≥ HS: 43%	No difference between groups in percent obese (unadjusted) (*P* = 0.31)
Cho et al., 2008[52] (companion: Lee et al., 2009[70]) Cross-sectional N = 489 Fair	Seniors who are patients at 1 of 2 Chicago, Illinois clinics s-TOFHLA Inadequate/ marginal: 51% adequate: 49%	• Race/ethnicity • Gender • Education	Health behavior measured through Health Promoting Lifestyle Profile relating to exercise, nutrition, and health responsibility	Using path analysis, HL level did not have a direct effect on health behavior (adjusted) (β = 0.07, *P* ≥ 0.05)
Wolf et al., 2006[105] Cross-sectional N = 251 Fair	Adults at a primary care clinic in Shreveport, Louisiana REALM Low: 30% Marginal: 31% Adequate: 40%	• Age • Gender • Race • Education • Number of prescriptions taken	Read/looked at medication guides and consumer information included with prescription medications Low: 17% Marginal: 22% Adequate: 33%	Low group more likely than adequate group to not read/look at medication guides (OR, 2.5; 95% CI, 1.2-5.2) No difference between marginal and adequate groups in likelihood of reading/looking at medication guides (*P* = NS, data NR)

Table 23. Summary of studies of the relationship between health literacy and health behaviors (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Paasche-Orlow, 2005[84] Cross-sectional N = 423 Fair	Female inmates in Rhode Island adult correctional institute REALM ≤ 6th grade: 10% 7th-8th grade: 19% ≥ 9th grade: 71%	• Age • Race • Problem drinking	HIV Risk Behavior in past 3 months (self-report of sex without a condom or shared injection drug equipment) ≤ 6th grade: 9% 7th-8th grade: 19% ≥ 9th grade: 72%	No difference between groups in HIV risk behaviors (adjusted) ≤ 6th grade versus≥ 9th grade (OR, 2.02; 95% CI, 0.83-4.92) ≤ 6th grade versus 7th -8th grade (OR, 1.89; 95% CI, 0.74 - 4.81)
Marteleto, 2008[76] Longitudinal N = 4,751 (wave 1) Fair	14-22 years old at time of Wave 1 in Cape Town, South Africa Cape Area Panel Study Literacy evaluation scores: NR	• Grades completed in 2002 • Enrolled in 2002 • Age • Age squared • Race • Income • Household shock • Mother's education • Father's education • Living with mother • Living with father	Sexual debut: NR First pregnancy: NR	An increase in literacy of one standard deviation associated with a 7.5% reduction in probability of sexual debut (adjusted) ($P < 0.05$). Literacy level not related to first pregnancy in either females or males (adjusted) Probit coefficient Females: 0.41 Males: -0.030

Table 24. Summary of studies of the relationship between health literacy and the outcome of health care related skills (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Setting and Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Level	Differences in Results Between Health Literacy Levels
Kripalani et al., 2006[68] Cross-sectional N = 152 Good	Clinic population with coronary heart disease in Atlanta, Georgia REALM Inadequate: 52% Marginal: 29% Adequate: 20%	• Age • Education • Cognitive functioning	DRUGS: Requiring observed completion of 4 tasks: 1. Identify appropriate medication 2. Open container 3. Select correct dose 4. Report appropriate timing of doses. Mean score: Inadequate: 92.1 Marginal: 96.3 Adequate: 97.7	Difference across groups in overall DRUGS score (unadjusted) (*P* = 0.001) Inadequate more likely than adequate to not be able to identify all medications (adjusted) (OR, 12.00; 95% CI, 2.57-56.08) No difference between marginal and adequate in ability to identify all medications (adjusted) (OR, 4.75; 95% CI, 0.95-23.75)
Raehl et al., 2006[90] Cross-sectional N = 57 Fair	Seniors in Amarillo, Texas REALM mean: 55.4	• Age • Number of over the counter drugs • Owned a car in last 10 years • Received food assistance in last 10 years	MedTake Test: ability to open and take own medications while observed by pharmacist MedTake Test outcomes: NR	A higher MedTake Test score was associated with a higher REALM score (adjusted): (*P* < 0.01)
Yin et al., 2007[106] Cross-sectional N = 292 Fair	Parents/ caregivers of children at an Emergency Department in New York City TOFHLA Inadequate: 10% Marginal: 16% Adequate: 74%	• Experience of ever receiving a dosing instrument in a health care setting • Child's age • Child has regular health care provider • Confounders with health literacy: • Caregiver's education, country of origin, language, socio-economic status	Self reported use of nonstandardized dosing instrument Inadequate/ Marginal: 35% Adequate: 19%	No difference in use of dosing instrument between health literacy groups (adjusted for all control variables) (OR, 1.5; 95% CI, 0.8-2.8) Marginal/ inadequate group greater use than adequate group (adjusted for control variables except for confounders with HL) (OR, 1.9; 95% CI, 1.0-3.5)

BMI, Body Mass Index; CI, confidence interval; DRUGS, Drug Regimen Unassisted Grading Scale; HIV, Human immunodeficiency virus; HL, health literacy; HS, high school; INR, International Normalized Ratio; N, number; NR, not reported; OR, odds ratio; REALM, rapid estimate of adult literacy in medicine; RR, risk ratio; TOFHLA, Test of Functional Health Literacy in Adults; SD, standard deviation; S-TOFHLA, short form Test of Functional Health Literacy in Adults.

Table 24. Summary of studies of the relationship between health literacy and the outcome of health care related skills (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Setting and Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Level	Differences in Results Between Health Literacy Levels
Estrada et al., 2004[54] Prospective cohort N = 143 Fair	Adults greater than 50 years old on warfarin ≥ 1 month in 2 anticoagulation management units REALM ≤ 3rd: 11% 4th-6th: 15% 7th-8th: 26% >8th: 48%	• Age	Warfarin control measured through INR variability: Data: NR Optimal intensity of anticoagulation (time in range) Data: NR	No difference by HL level in INR variability (adjusted) (*P* = 0.06) No difference by HL time INR in therapeutic range (adjusted) (*P* = 0.71)
Wolf et al., 2006[45] (Analysis 1) Wolf et al., 2007[46] Cross-sectional N = 395 Fair	Adults in primary care clinics in Shreveport LA, Jackson MI, and Chicago, IL REALM Inadequate: 19% Marginal: 29% Adequate: 52%	Analysis 1 • Age • Sex • Race • Education • Number of medications currently taken daily • Site Analysis 2 None	Misunderstood one or more prescription label instructions: Inadequate: 63% Marginal: 51% Adequate: 38% Correct demonstration of number of pills: Inadequate: 35% Marginal: 63% Adequate: 80%	Analysis 1 Greater misunderstanding in inadequate compared to adequate group (adjusted) (RR, 2.32; 95% CI, 1.26-4.28) Greater misunderstanding in marginal compared to adequate group (adjusted) (RR, 1.94; 95% CI, 1.14-3.27 Greater demonstration of pills in adequate compared to inadequate group (adjusted): (RR, 3.02; 95% CI, 1.70-4.89) No difference between marginal and adequate groups in demonstration of pills (RR = NS, data not reported) Analysis 2 Difference across literacy groups in correctly interpreting primary label (unadjusted) Amoxicillin: (*P* < 0.001) Trimethoprim: (*P* < 0.001)

Table 24. Summary of studies of the relationship between health literacy and the outcome of health care related skills (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Setting and Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Level	Differences in Results Between Health Literacy Levels
Wolf et al., 2006[45] (Analysis 1) Wolf et al., 2007[46] Cross-sectional (continued)				Guaifenesin: ($P < 0.001$) Felodipine: ($P = 0.03$) Furosemide: ($P = 0.09$) Difference across literacy groups in correctly attending to auxiliary label (unadjusted) Amoxicillin: ($P = 0.13$) Trimethoprim: ($P = 0.14$) Guaifenesin: ($P < 0.001$) Felodipine: ($P = 0.11$) Furosemide: ($P = 0.01$)
Rothman et al., 2006[8] Cross-sectional N = 200 Fair	Adults in primary care clinic REALM < HS: 23% ≥ HS: 77%	• Age • Gender • Race/ethnicity • Income • Education • Insurance status • Presence of chronic disease • Status of being on a specific diet • Label reading frequency	Understanding nutrition labels measured through Nutrition Label Survey Nutritional Label Survey score mean (SD): < HS: 51 (16) ≥ HS: 75 (19)	Greater understanding of nutrition labels in higher HL group (adjusted): ($P < 0.001$)
LeVine et al., 2004[71] Cross-sectional N = 167 Fair	Mothers of kindergarten age children in urban and rural Nepal Literacy measured as continuous, composite score of reading comprehension and noun definition (in Nepalese) Levels NR	• Maternal schooling • Childhood socioeconomic status • Age • Current socioeconomic status • Husband's schooling • Urban/rural	Comprehension of radio health messages Comprehension of visual print health message Ability to give an organized health related narrative Data: NR	Higher literacy level associated with greater probability of giving an organized health narrative (adjusted) ($P < 0.05$)
Paasche-Orlow et al., 2005[83] Cross-sectional N = 73 Fair	Inpatient adults hospitalized for severe asthma at 2 inner city hospitals s-TOFHLA Inadequate: 22% Adequate: 78%	• Age • Sex • Ethnicity • Education • Income • History of near fatal asthma • Asthma hospitalization in prior 12 months	Mastery of metered dose inhaler technique Inadequate: 32% Adequate: 63%	Poorer probability of mastery of metered dose inhaler in inadequate than adequate group (adjusted) (OR 0.29, 95% CI, 0.08-1.00) ($P = 0.03$)

Table 24. Summary of studies of the relationship between health literacy and the outcome of health care related skills (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Setting and Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Results By Health Literacy Level	Differences in Results Between Health Literacy Levels
Paasche-Orlow et al., 2005[83] (continued)		• Having a physician for asthma care • Prior emergency department visit for asthma last 12 months (subset of confounders used in final model specification NR)		

Table 25. Summary of studies of the relationship between health literacy and the outcome of prevalence of depression and other mental health outcomes (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Lincoln et al., 2006[72] Prospective cohort N = 390 Fair	Adults in an inner-city short-term inpatient detoxification unit REALM Low: 46% Higher: 54%	Time Sex Age Race Education Income Primary language Primary substance of choice Randomization group Mini-mental status exam Baseline outcomes variable	Baseline CES-D: mean (SD) Low: 30.9 (11.3) Higher: 34.8 (13.32) ASI-Alc Low: 0.46 (0.34) High: 0.48 (0.34) ASI-Drug Low: 0.26 (0.13) High: 0.26 (0.15)	Depressive symptomatology No difference between groups (adjusted cross sectional analysis) (P = 0.09) Lower group greater (adjusted longitudinal analysis) (P < 0.01) Alcohol addiction severity No difference between groups (adjusted cross sectional analysis) (P = 0.88) No difference between groups (adjusted longitudinal analysis) (P = 0.86) Drug addiction severity No difference between groups (adjusted cross sectional analysis) (P = 0.11) No difference between groups (adjusted longitudinal analysis) (P = 0.35)
Nokes et al., 2007[82] Cross-sectional N = 489 Fair	HIV positive adults receiving care in San Francisco, Fresno, Richmond, NYC, Corpus Christi REALM Mean = 59.1 (SD, 12.9)	Hispanic	Depressive symptomatology, Distress over body changes Data NR	Depressive symptomatology worse in higher health literacy group (adjusted) (P < 0.05) Distress over body changes greater in higher health literacy group (adjusted) (β= 2.91, P < 0.05)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 25. Summary of studies of the relationship between health literacy and the outcome of prevalence of depression and other mental health outcomes (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Bennett et al., 2007[49] Cross-sectional N = 99 Fair	Pregnant patients Receiving prenatal care in clinics in Philadelphia S-TOFHLA-Spanish Inadequate: 18% Marginal: 15% Adequate: 67%	Mexican nativity Recent marijuana use	Elevated depressive symptomatology (CES-D ≥ 16) Inadequate HL: 44% Marginal HL: 33% Adequate HL: 18%	Inadequate group more likely than adequate group to have depressive symptomatology (adjusted) (PR: 2.39; 95% CI, 1.07–5.35) No difference in depressive symptomatology between marginal and adequate groups (adjusted) (PR: 1.73; 95% CI, 0.75-4.02)
Kalichman et al., 2008[67] Cross-sectional N = 145 Fair	HIV positive adults in Atlanta, Georgia TOFHLA Lower: 49% Higher: 51%	None	Depression: Mean (SD) Lower: 10.9 (6.6) Higher: 8.7 (7.8)	No difference between groups in rate of depression (unadjusted) (OR: 0.95; 95% CI, 0.91-1.00)
Walker et al., 2007[101] Cross-sectional N = 363 Fair	Patients at 3 rheumatology clinics in the United Kingdom REALM Lower (< 60): 15% Adequate (≥ 60): 85%	None	Hospital Anxiety and Depression scales (HAQ and HAD) Depression, mean Lower:8.1 Adequate: 6.5 Anxiety, mean Lower: 9.4 Adequate: 7.7	Anxiety higher in lower group (unadjusted): (P = 0.03) Depression higher in lower group (unadjusted) (P = 0.01)
Morris et al., 2006[79] Cross-sectional N = 1,002 Good	Adults with diabetes in primary care practices in Vermont STOFHLA Inadequate: 10% Marginal: 7% Adequate: 83%	None	Depression, Patient Health Questionnaire > 5 Inadequate: 40% Marginal: 54% Adequate: 31% Depression, median Patient Health Questionnaire Score Inadequate: 3 Marginal: 5 Adequate: 2	Difference across groups in depression (PHQ > 5) (unadjusted) (P = 0.03) Difference across groups in median depression score (unadjusted) (P = 0.04)

Table 25. Summary of studies of the relationship between health literacy and the outcome of prevalence of depression and other mental health outcomes (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Sudore et al., 2006[96] (companion: Sudore et al., 2006[95]) Cross-sectional N = 2,512 Fair	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM 0-6th grade: 8% 7-8th grade: 15% ≥9th grade: 76%	None	Depression 0-6th grade: 6% 7th-8th grade: 3% ≥ 9th grade: 2%	Difference in probability of depression across groups (unadjusted) (OR: 2.54, 95% CI; 1.47, 4.42)
Howard et al., 2005[41] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Baker et al., 2004[35]) Cohort N = 3,260 Good	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Adequate: 64% Marginal: 11% Inadequate: 24%	None	Depression Inadequate: 19% Marginal: 14% Adequate: 12%	Difference between groups in rate of depression (unadjusted) ($P < 0.0001$)

Table 26. Summary of studies of the relationship between health literacy and the outcome of prevalence of chronic diseases (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Sentell and Halpin, 2006[92] Cross-sectional N = 23,889 Fair	National sample of adults Total NALS score Level 1: 20% Level 2: 27% Level 3: 34% Level 4: 18% Level 5: 2%	• Race • Education • Understand English • Born in U.S.A. • Unemployed • Family income • Income missing • Sex • Age • Married • Get food stamps • Live in Metropolitan Statistical Area • Region	Self report of physical, mental, or other health condition that keeps respondent from working Data: NR Long-term illness (greater than 6 months) Data: NR	Lower health literacy associated with greater odds of having a condition that keeps respondent from working (adjusted) (OR, 1.11, 95% CI, 1.08-1.14) Lower health literacy associated with greater odds of having a long-term illness (adjusted) (OR 1.04, 95% CI, 1.02-1.04)
Baker et al., 2007[38] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Prospective cohort N = 3,260 Good	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Inadequate: 24% Marginal: 11% Adequate: 64%	None	Number of chronic conditions Inadequate: mean 1.7 (SD=1.2) Marginal: mean = 1.7 (SD=1.2) Adequate: mean = 1.5 (SD=1.2)	No difference between the groups in number of chronic conditions (unadjusted) (P = 0.87)
Rothman et al., 2006[8] Cross-sectional N = 200 Fair	Adults in a primary care clinic REALM < HS: 23% ≥ HS: 77%	None	Chronic illness (hypertension, coronary artery disease, high cholesterol, diabetes, or heart failure): < HS: 52% ≥ HS: 38%	No difference between groups in percent with chronic illness (unadjusted) (P = 0.08)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 26. Summary of studies of the relationship between health literacy and the outcome of prevalence of chronic diseases (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Wolf et al., 2005[39] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 200;7[38] Howard et al., 2006;[36] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Cross-sectional N = 2,923 Fair	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S- TOFHLA Adequate: 67% Marginal: 11% Inadequate: 22%	• Age • Sex • Race/ethnicity • Income • Education • Tobacco • Alcohol consumption • Self-reported comorbid conditions	Hypertension Inadequate:50% Marginal: 46% Adequate: 43% Diabetes Inadequate: 19% Marginal: 15% Adequate: 13% Coronary artery disease Inadequate: 6% Marginal: 7% Adequate: 8% Heart failure Inadequate: 6% Marginal: 4% Adequate: 4% Bronchitis or emphysema Inadequate: 10% Marginal: 10% Adequate: 14% Asthma Inadequate: 7% Marginal: 8% Adequate: 7% Arthritis Inadequate: 57% Marginal: 57% Adequate: 50% Cancer Inadequate: 4% Marginal: 7% Adequate: 6%	Self reported prevalence of chronic disease (adjusted): No difference in rates of hypertension between inadequate and adequate groups (OR 1.20; 95%CI, 0.95-1.50) No difference in probability of hypertension between marginal and adequate groups (OR 1.03; 95%CI, 0.80-1.34) Inadequate group had a significantly higher rate of diabetes than adequate group (OR 1.48; 95%CI, 1.09-2.02) No difference in probability of diabetes between marginal and adequate groups (OR 1.10; 95%CI, 0.75-1.59) No difference in coronary artery disease between inadequate and adequate groups (OR 0.93; 95%CI, 0.59-1.47) No difference in coronary artery disease between marginal and adequate groups (OR 0.85; 95%CI, 0.51-1.43 Inadequate group has a higher probability of heart failure than adequate group (OR 1.69; 95%CI, 1.02-2.80) No difference in heart failure between marginal and adequate groups (OR 0.97; 95%CI, 0.49-1.90) No difference in bronchitis or emphysema between inadequate and adequate groups (OR 0.75; 95%CI 0.53-1.08)

Table 26. Summary of studies of the relationship between health literacy and the outcome of prevalence of chronic diseases (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Wolf et al., 2005[39] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 200;7[38] Howard et al., 2006;[36] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) (continued)				No difference in bronchitis or emphysema between marginal and adequate groups (OR 0.81; 95%CI, 0.53-1.22) No difference in asthma between inadequate and adequate groups. (OR 0.96; 95%CI, 0.62-1.37) No difference in asthma between marginal and adequate groups (OR 1.26; 95%CI, 0.79-2.01) No difference in arthritis between inadequate and adequate groups (OR 0.98 95%CI, 0.78-1.23) No difference in arthritis between marginal and adequate groups (OR 1.11; 95%CI, 0.85-1.44) No difference in cancer between inadequate and adequate groups (OR 0.91; 95%CI, 0.54-1.52) No difference in cancer between marginal and adequate groups. (OR 1.38; 95%CI, 0.84-2.27)
Howard et al., 2005[41] (companion: Gazmararian, 2006;[34] Wolf et al., 2007[37] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Baker et al., 2004[35]) Cohort N = 3,260 Good	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Adequate: 64% Marginal: 11% Inadequate: 24%	None	Heart Attack Inadequate: 15% Marginal: 18% Adequate: 13% Angina Inadequate: 8% Marginal: 12% Adequate: 8% Stroke Inadequate: 13% Marginal: 9% Adequate: 7% COPD Inadequate: 14% Marginal: 16% Adequate: 18%	Difference between groups in heart attack rate (unadjusted) (P = 0.01) No differences between groups in rate of angina (unadjusted) (P = 0.06) Difference between groups in rate of stroke (unadjusted) (P < 0.0001) No differences between groups in rate of COPD (unadjusted) (P = 0.06)

Table 26. Summary of studies of the relationship between health literacy and the outcome of prevalence of chronic diseases (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Sudore et al., 2006[96] (companion: Sudore et al., 2006[95]) Cross-sectional N = 2,512 Fair	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM 0-6th grade: 8% 7-8th grade: 15% ≥ 9th grade: 76%	None	Hypertension 0-6th grade: 62% 7th-8th grade: 63% ≥ 9th grade: 55% Diabetes 0-6th grade: 25% 7th-8th grade: 26% ≥9th grade: 15%	Difference in probability of hypertension across groups (unadjusted) (OR: 1.39, 95% CI: 1.25, 1.68) Difference in probability of diabetes across groups (unadjusted) (OR: 1.98, 95% CI: 1.58, 2.48)

Table 27. Summary of studies of the relationship between health literacy and HIV Patient Symptoms (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Paasche-Orlow et al., 2006[85] Retrospective cohort N = 235 Fair	Patients with HIV and a history of alcohol problems in Boston, Massachusetts REALM Low: 14% Marginal: 29% Adequate: 57%	• Gender • Age • Education • Randomization group • Ethnicity • Homeless status • Drank to intoxication past 30 days • Injected drugs past 6 months • Complexity of regimen • Medication adherence	Viral load suppressed Low: 63% Marginal: 58% Adequate: 61%	Viral load (HIV-RNA) suppression No difference between low and adequate groups (adjusted): (OR 1.70, 95% CI, 0.79-3.65) No difference between marginal and adequate groups (adjusted): (OR 1.29, 95% CI, 0.77-2.18)
Mayben et al., 2007[77] Cross-sectional N = 119 Fair	Adults with HIV receiving care at 4 publicly funded clinics in Houston, Texas TOFLHA Inadequate: 28% Adequate: 72%	• Gender • Reason for getting Tested • Marijuana use	CD4 cell count: median (interquartile range) Inadequate: 175 (69, 272) Adequate: 247(31, 517)	No difference in CD4 cell count between adequate and inadequate groups (adjusted) (P = 0.35)
Nokes et al., 2007[82] Cross-sectional N = 489 Fair	HIV positive adults receiving care in San Francisco, Fresno, Richmond, NYC, Corpus Christi REALM Mean = 59.1 (SD, 12.9)	• Hispanic	HIV-symptom intensity Data NR	HIV-symptom intensity greater in higher health literacy group (adjusted) (β= 8.62, P < 0.05)
Kalichman et al., 2008[67] Cross-sectional N = 145 Fair	HIV positive adults in Atlanta, Georgia TOFHLA Lower: 49% Higher: 51%	None	HIV symptoms: Mean (SD) Lower: 4.0 (3.2) Higher: 4.7 (3.9)	No difference between groups in number of HIV symptoms (unadjusted) (OR= 1.05; 95% CI, 0.95-1.14)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 28. Summary of studies of the relationship between health literacy and Asthma Patient Symptoms (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Shone et al., 2009[93] Cross-sectional N = 499 Fair	Parents of children with persistent asthma in Rochester New York School District REALM Low: 33% Adequate: 67%	• Child health insurance • Parent's employment, ethnicity, and race	Asthma is not under good control: Low: 76% Adequate: 82% Child's health is fair/poor Low: 39% Adequate: 17%	No difference between groups in rate of asthma not under good control (unadjusted) (P = 0.094) Parents' in low group more likely to have child with fair/poor health (adjusted) (OR, 3.96, 95% CI, 2.4-6.4)
DeWalt et al., 2007[53] Cross-sectional N = 150 Fair	Parents of children with asthma receiving care at 3 clinics in North Carolina REALM Lower: 24% Higher: 76%	None	Albuterol Use (mean days per week): Lower: 2.7 Higher: 1.5 Albuterol Use (total mean use per week): Lower: 6 doses Higher: 3 doses Appropriate Controller Use: Lower: 68% Higher: 82%	Greater Albuterol use in children of parents in lower compared to higher health literacy group (unadjusted) (P = 0.01) Greater total weekly Albuterol use in children of parents in lower compared to higher health literacy group (unadjusted) (P = 0.03) No difference between groups in appropriate controller use (unadjusted) (P = 0.15)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 29. Summary of studies of the relationship between health literacy and diabetes control (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Morris et al., 2006[79] Cross-sectional N = 1,002 Good	Adults with diabetes in primary care practices in Vermont STOFHLA Inadequate: 10% Marginal: 7% Adequate: 83%	• Age • Sex • Race • Marital status • Insurance • Income • Duration of diabetes • Diabetes education • Depression • Alcohol use • Medication use • Physician practice	HbA1c median Inadequate: 6.9% Marginal: 6.8% Adequate: 6.9% SBP median Inadequate:137 Marginal: 144 Adequate: 138 DBP median Inadequate: 76 Marginal: 77 Adequate: 79 LDL-cholesterol median Inadequate: 99 Marginal: 94 Adequate: 99 Retinopathy Inadequate: 30% Marginal: 34% Adequate: 18% Nephropathy Inadequate: 15% Marginal: 0 Adequate: 9% Gastroparesis Inadequate: 9% Marginal: 6% Adequate: 6% Foot/leg problems Inadequate: 30% Marginal: 30% Adequate: 30% Cerebrovascular disease Inadequate: 21% Marginal: 17% Adequate: 10%	No difference in HbA1c levels across groups (adjusted, continuous TOHFLA scores used) (P = 0.88) No difference in SBP across groups (adjusted, continuous TOHFLA scores used) (P = 0.78) No difference in DBP across groups (adjusted, continuous TOHFLA scores used) (P = 0.39) No difference in LDL-cholesterol across groups (adjusted, continuous TOHFLA scores used) (P = 0.59) Retinopathy rates No difference between inadequate and adequate group (adjusted) (OR 1.88, 95% CI, 0.90-3.91) No difference between marginal and adequate groups (adjusted) (OR 2.30, 95% CI, 0.63-8.44) Nephropathy No difference between inadequate and adequate groups (adjusted) (OR 1.05, 95% CI, 0.39-2.80)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 29. Summary of studies of the relationship between health literacy and diabetes control (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Morris et al., 2006[79] (continued)			Coronary artery disease Inadequate: 30% Marginal: 27% Adequate: 17%	No difference between marginal and adequate groups (adjusted) (OR 0.99, 95% CI, 0.95-1.03) Foot/leg problem rates No difference between inadequate and adequate groups (adjusted) (OR 0.52, 95% CI, 0.24-1.16) No difference between marginal and adequate groups (adjusted) (OR 1.39, 95% CI, 0.47-4.12) Gastroparesis No difference between inadequate and adequate groups (adjusted) (OR 1.92, 95% CI, 0.58-6.36) No difference between marginal and adequate groups (adjusted) (OR 1.98, 95% CI, 0.26-18.07) Cerebrovascular disease No difference between inadequate and adequate groups (adjusted) (OR 0.86, 95% CI, 0.39-1.91) No difference between marginal and adequate groups (adjusted) (OR 0.65, 95% CI, 1.66-2.57) Coronary artery disease

Table 29. Summary of studies of the relationship between health literacy and diabetes control (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Morris et al., 2006[79] (continued)		•		No difference between inadequate and adequate groups (adjusted) (OR 0.76, 95% CI, 0.36-1.63) No difference between marginal and adequate groups (adjusted) (OR 1.12, 95% CI, 0.34-3.70)
Tang et al., 2007[97] Cross-sectional survey and medical chart review N = 149 Fair	Adults with diabetes in diabetes education management center of a public hospital in Hong Kong Chinese S-TOFHLA: Levels NR	• Gender • Insurance • Duration of diabetes • Patient awareness score • C-SDSCA (management of diabetes)	HbA1c levels outcomes: NR	Higher health literacy associated with lower HbA1c levels (adjusted) ($P < 0.001$)
Powell et al., 2009[88] Cross-sectional N = 68 Fair	Patients with Type 2 diabetes treated in general internal medicine clinic REALM: < 4th grade: 13% 4th-6th grade: 25% 7th-8th grade: 19% High school: 43%	• Education • Age • Race • Gender • Treatment regimen	HbA1c Median <4th grade: 8% 4th-6th grade: 8% 7th-8th grade: 10% HS: Median: 7.9%	Difference in HbA1c level between groups (adjusted) ($P = 0.02$)
Schillinger et al., 2006[91] Cross-sectional N = 395 Good	Adult diabetes patients (> 30 years old) treated at one of two primary care clinics at San Francisco General Hospital S-TOFHLA Mean = 20.6 (SD=12.1)	• Age • Primary language other than English • Insurance • Education	Log HbA1c Data: NR	Health literacy mediated the direct relationship between education and HbA1c level in a partial mediation model (adjusted Path analysis) ($P < 0.05$) Health literacy mediated the direct relationship between education and HbA1c level in a full mediation model (adjusted Path analysis) ($P = 0.03$)

Table 29. Summary of studies of the relationship between health literacy and diabetes control (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Laramee et al., 2007[69] Cross-sectional N = 998 Fair	Adults with diabetes in primary care practices in Vermont, New Hampshire, and northern New York State S-TOFHLA Limited: 17% Adequate: 83%	None	Heart failure Limited: 27% Adequate: 15%	Limited group higher rate of heart failure (unadjusted): (OR 2.05; 95% CI, 1.39-3.02)

Table 30. Summary of studies of the relationship between health literacy and hypertension control (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Powers et al., 2008[89] Cross-sectional N = 1,224 Fair	Patients with hypertension receiving primary care in the VA healthcare system and Duke University Healthcare system in Durham, NC. REALM VA Limited: 38% Adequate: 58% Duke Limited: 28% Adequate: 72%	• Age • Race • Marital status • Education • Adequacy of income • Diabetic status • Medication Adherence • Smoking • Exercise • Participatory decision-making score	SBP: mean (SD) VA Limited: 138.7 (17.8) Adequate: 138.4 (17.5) Duke Limited: 142 (24.9) Adequate: 133 (17.6)	No difference between groups in SBP (adjusted) (β = -1.2; 95% CI, -4.8-2.3)
Pandit et al., 2009[86] Cross-sectional N = 330 Fair	Adults with hypertension receiving primary care from clinics in Grand Rapids, Michigan, Chicago, Illinois, and Shreveport, Louisiana	• Age • Race • Gender • Marital status • Employment status • Insurance coverage • Site location	Controlled Blood Pressure Category I: 34% Category II: 49% Category III: 45% Category IV: 61% Category V: 46% (highest)	Category V group has greater odds of having controlled BP than Category I group (adjusted) (RR, 2.68, 95% CI, 1.54-4.70)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD, Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish, VA, Veterans Affairs.

Table 30. Summary of studies of the relationship between health literacy and hypertension control (KQ 1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Pandit et al., 2009[86] (continued)	S-TOFHLA Category I: 17% Category II: 11% Category III: 16% Category IV: 26% Category V: 31%	• Number of comorbid conditions • Years treated for hypertension • Clinic site • Education		No difference between Category II and Category V in odds of having controlled BP (adjusted) (RR, 1.47, 95% CI, 0.53-4.05) Category V group has greater odds of having controlled BP than Category III group (adjusted) (RR, 1.69, 95% CI, 1.08-2.63) No difference between Category IV and Category V in odds of having controlled BP (adjusted) (RR, 1.10, 95% CI, 0.40-3.01)

Table 31. Summary of studies of the relationship between health literacy and prostate cancer control (KQ 1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Setting and Population by Health Literacy Level	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Outcomes Between Health Literacy Levels
Wolf et al., 2006[104] Cross-sectional N = 308 Good	Patients with newly diagnosed prostate cancer in 4 outpatient oncology and urology clinics in Chicago area REALM Low: 18% Marginal: 33% Functional: 50%	• Age • Race • Annual income • Marital status	PSA Level > 20 ng/mL Marginal: 24% Low: 33% Functional: 14%	Low group more likely to have elevated PSA than functional group (adjusted) (OR, 2.5; 95% CI, 1.5-4.2) No difference in rates of elevated PSA between marginal and functional groups (adjusted) (OR, 1.4; 95% CI, 0.9-2.2)

ASI-Alc, Addiction Severity Index - Alcohol; ASI-Drug, Addiction Severity Index - Drugs; CES-D, Center for Epidemiology Studies – Depression Scale; COPD,Chronic Obstructive Pulmonary Disease; PR, Poisson Regression coefficient; REALM, Rapid Estimate of Adult Literacy in Medicine; S-TOFHLA-Spanish, Short Test of Functional Health Literacy in Adults – Spanish.

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Smith and Haggerty, 2003[94] Cross-sectional N = 229 Fair	Adults in University-affiliated family practice center in Montreal, Canada REALM Low: 6% Adequate: 94%	• Age • Smoking status • Maternal language	Perceived overall health Low: mean = 3.3 Adequate: mean = 3.0	No difference between groups in perceived general health (adjusted): (β = -0.11; 95% CI, -0.25-0.03)
Bennett et al., 2009[50] (companion: White et al., 2008[103]) Cross-sectional N = 2,668 Good	Nationally representative sample of U.S. population, 65 years and older NAAL Below Basic: 29.0% Basic: 29.5% Intermediate: 38.2 Proficient 3.3%	Race Income Gender Age Nativity	Health status levels by health literacy level: NR	Higher health literacy associated with better self-reported health status (adjusted) ($P < 0.05$)
Analysis 1: Cho et al., 2008[52] Cross-sectional N = 489 Fair Analysis 2: Lee, 2009[70] Cross-sectional N = 489 Fair	Seniors who are patients at 1 of 2 Chicago, Illinois clinics s-TOFHLA Inadequate/marginal: 51% adequate: 49%	Analysis 1: • Race/ethnicity • Gender • Education Analysis 2: • Age • Gender • Race • Education • Marital status Income • Social support level	Health status (self report) Levels: NR General health (self report) Levels: NR Physical health (SF-12) Levels: NR Mental health (SF-12) Levels: NR	Analysis 1 Using path analysis, higher health literacy level related to better health status (adjusted) ($P < 0.05$) Analysis 2 Low health literacy associated with lower level of general health status(adjusted) ($P < 0.05$) No difference between groups in physical health (adjusted) (P = NS) No difference between groups in mental health (adjusted) (P = NS)

ADL, activities of daily living; AQLQ, Asthma Quality of Life Questionnaire; BMI, body mass index; FACT-G, Functional Assessment of Cancer Therapy-General; HR, Hazard ratio; HRQoL, health-related quality of life; IADL, Instrumental activities of daily living; NAAL, National Assessment of Adult Literacy; NALS, National Adult Literacy Survey; OR, Odds ratio; PCS, Physical Component Summary; SF, short form; VRQoL, vision-related quality of life.

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Analysis 1: Howard, 2006[36] Cohort N = 3,260 Fair Analysis 2: Baker et al., 2007[38] (companions: Gazmararian, 2006;[34] Wolf et al., 2007;[37]	New Prudential Medicare managed-care enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 25% Marginal: 11% Adequate: 64%	Analysis 1: • Age • Gender • Race/ethnicity • Education • Income • Site • Morbidity • Smoker Analysis 2: • Baseline measures: • Number of chronic conditions • Physical health score	Physical HRQoL (SF-12) Inadequate: mean = 41.9 (SD=11.9) Marginal: mean = 43.6 (SD=11.7) Adequate: mean = 46.2 (SD=10.7) Mental HRQoL (SF-12) Inadequate: mean 52.1 (SD=10.7) Marginal: mean = 54.9 (SD=9.2) Adequate: mean 55.5 (SD=7.9)	Analysis 1 Inadequate group poorer physical HRQoL than adequate (adjusted): (P < 0.001) Marginal group poorer physical HRQoL than adequate (adjusted) (P =0.019) Inadequate group poorer mental HRQoL than adequate (adjusted) (P < 0.001)
Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Prospective cohort N = 3,260 Good		• Mental health score • IADL limitation • ADL limitation • Smoking • Alcohol use • Vigorous physical activity • BMI	IADL limitation Inadequate: 46% Marginal: 37% Adequate: 24% ADL limitation Inadequate: 9% Marginal: 6% Adequate: 3%	No difference in mental HRQoL between marginal and adequate groups (adjusted) (P = 0.304) Inadequate group less likely to self-report health status of good or better than adequate groups (adjusted): (OR: 0.71, P = 0.004) No differences in self-reported health status of good or better between marginal and adequate groups (adjusted) (OR: 0.77, P = 0.060) Analysis 2 Significant difference between 3 HL groups in IADL limitation (unadjusted) (P < 0.001) Significant difference between 3 HL groups in ADL limitation (unadjusted) (P < 0.001)

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Sudore et al., 2006[96] (companion: Sudore, 2006[95]) Cross-sectional N = 2,512 Fair	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM 0-6th grade: 8% 7-8th grade: 15% ≥9th grade: 76%	None	Self report poor health 0-6th grade: 33% 7th-8th grade: 28% ≥ 9th grade: 14%	Difference in probability of poor health across groups (unadjusted) (OR: 2.60, 95% CI: 2.09, 3.23)
Wolf et al., 2005[39] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 2007;[38] Howard et al., 2005;[41] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Cross-sectional N = 2,923 Fair	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S- TOFHLA Inadequate: 22% Marginal: 11% Adequate: 67%	• Age • Sex • Race/ethnicity • Income • Education • Tobacco • Alcohol consumption • Self-reported comorbid conditions	Physical function (SF-36) mean (SD) Inadequate: 67.7 (9.7) Marginal: 73.7 (27.5) Adequate: 78.0 (24.6) Mental health functioning (SF-36) mean (SD) Inadequate: 76.2 (20.9) Marginal: 81.8 (18.6) Adequate: 84.0 (16.1)	Inadequate group lower physical function scores than adequate group (adjusted): (β = -6; 95%CI, -8.4 - -3.5) Marginal lower physical function scores than adequate group (adjusted) (β = -1.1; 95%CI, -3.9 -1.8) Inadequate group lower mental health scores than adequate group (adjusted) (β = -4.9; 95%CI, -6.7- -3.1) Marginal group lower mental health score than adequate group (adjusted including education) (β = -0.9; 95%CI, -2.9-1.2) Inadequate group has greater self-reported instrumental activity limitations than adequate group (adjusted including ed): (OR 2.25; 95%CI, 1.74-2.92) Marginal group has greater instrumental activity limitations than adequate group (OR 1.65; 95%CI, 1.22-2.24)

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Wolf et al., 2005[39] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 2007;[38] Howard et al., 2005;[41] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) (continued)				Inadequate group has greater self-reported activity limitations than adequate group (adjusted including ed): (OR 2.83; 95%CI, 1.62-4.96) Marginal group has greater activity limitations than adequate group (adjusted): (OR 2.05; 95%CI, 1.06-3.97) Inadequate group has greater limitations due to physical health than adequate group (adjusted): (OR 1.79; 95%CI, 1.39-2.32) No differences in limitations because of physical health between adequate and marginal groups (adjusted): (OR 1.35; 95%CI, 1.00-1.84) Inadequate group has fewer accomplishments due to physical health than adequate group (adjusted): (OR 1.90; 95%CI, 1.48-2.45) Marginal has fewer accomplishments than marginal group (adjusted): (OR 1.46; 95%CI, 1.08-1.97) Inadequate group has greater pain interfering with activities than adequate group (adjusted): (OR 2.01; 95%CI, 1.46-2.77) No difference in pain interfering with activities between marginal and adequate groups (adjusted): (OR 1.23; 95%CI, 0.83-1.82)

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Muir et al., 2008[80] Cross sectional N = 110 Fair	Glaucoma patients at a Duke eye clinic in Durham, North Carolina REALM Low: 52% Adequate: 48%	• Age • Race • Visual acuity • Visual field • Education	VRQoL Score (mean) Low: 84 Adequate: 76 Physical HRQoL (SF-12) Data NR Mental HRQoL (SF-12) Data NR	No difference between groups in VRQoL (adjusted) (*P* = 0.621) Low health literacy associated with poorer physical HRQoL (unadjusted) (*P* = 0.002) No difference between groups in mental HRQoL (unadjusted) (*P* = 0.068)
Nokes et al., 2007[82] Cross-sectional N = 489 Fair	HIV positive adults receiving care in San Francisco, Fresno, Richmond, NYC, Corpus Christi REALM Mean = 59.1 (SD, 12.9)	• Hispanic	Global physical health (scale developed by investigators): mean (SD) Lower: 7.21, (2.42) Higher: 6.68, (2.22)	Physical health rated lower in higher group (unadjusted) (*P* =.02)
Mancuso and Rincon, 2006[74] Cross-sectional N = 175 Fair	Adults with asthma enrolled in a primary care practice in New York City TOFHLA Adequate: 82% Marginal: 8% Inadequate: 10%	• Asthma severity • asthma self-efficacy • Age • Education • Depressive symptoms • Asthma knowledge	Outcome data by health literacy level: NR	Lower health literacy related to poorer AQLQ (adjusting for asthma severity, asthma self-efficacy) (*P* = 0.003) Lower HL related to poorer AQLQ (adjusting for asthma severity, asthma self-efficacy, age and education) (*P* = 0.03) No difference in AQLQ by HL level (adjusting for asthma severity, asthma self-efficacy, age, education, depressive symptoms) (*P* = 0.07) No difference in AQLQ by HL level (adjusting for asthma severity, asthma self-efficacy, age, education, depressive symptoms, asthma knowledge) (*P* = 0.38) Lower HL related to poorer Physical HRQoL (SF-36) (adjusting for asthma severity and asthma self-efficacy) (*P* = 0.0003)

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Mancuso and Rincon, 2006[74] (continued)				No difference in Physical HRQoL (SF-36) by HL level (adjusting for asthma severity, asthma self-efficacy, age and education) (*P* = 0.11) No difference in Physical HRQoL (SF-36) by health literacy level (adjusting for asthma severity, asthma self-efficacy, age, education and depressive symptoms) (*P* = 0.22) No difference in SF-36 by HL level (adjusting for asthma severity, asthma self-efficacy, age, education, depressive symptoms and asthma knowledge) (*P* = 0.53)
Johnson et al., 2005[66] Cross-sectional N = 107 Fair	Adult patients at spinal cord injury clinic in New Jersey TOFHLA Inadequate: 6% Marginal 8% Adequate: 86%	• Motor index • Education	Outcome data by health literacy level: NR	Having less than adequate health literacy associated with poorer physical morbidity (number of days physical health "not good") (adjusted) (*P* < = 0.05) No difference between groups in mental health morbidity (number of days mental health "not good") (adjusted) (*P* = 0.90) No difference between groups in SF-12 Physical Component score (adjusted) (*P* = 0.49) No difference between groups in SF-12 Mental Component score (adjusted) (*P* = 0.07) No difference between groups in physical independence (adjusted) (*P* = 0.47) No difference between groups in mobility (adjusted) (*P* = 0.93)

Table 32. Summary of studies of the relationship between health literacy and health status (KQ1b) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Hahn et al., 2007[61] Cross-sectional N = 415 Good	Adult cancer patients in 5 Chicago area cancer centers Passage comprehension subtest of Woodcock Language Proficiency Battery Low: 52% High: 48%	• Age • Gender • Race/ethnicity • Work status • Marital status • Living arrangement • Socioeconomic status • Prior computer experience • Cancer diagnosis • Stage at diagnosis • Months since diagnosis • Current chemotherapy treatment • Performance status	FACT-G: mean (SD) Physical Well-being Low: 17.9 (5.9) High: 18.4 (5.8) Emotional Well-being Low: 17.6 (5.2) High:17.5 (4.7) Functional Well-being: Low: 15.7 (6.5) High: 16.0 (6.3) SF-36: mean (SD) Physical Functioning Low: 48.7 (26.7) High: 57.2 (27.5) Role-Physical Low: 29.7 (38.2) High: 34.8 (42.4) Bodily Pain Low: 55.5 (26.9) High: 56.0 (24.9) General Health Low: 49.9 (20.6) High: 53.2 (21.3) Vitality Low: 51.5 (21.4) High: 47.3 (20.5) Mental Health Low: 65.5 (19.6) High: 66.9 (20.2) Fair/Poor Health Low: 53.3% High: 39% Standard Gamble utility score Low: mean = 0.87 (0.20) High: mean = 0.85 (0.23)	No difference between groups on any of the FACT-G scale items (adjusted) No difference between groups on SF-36 including and excluding biased scale items (adjusted) Difference Standard Gamble utility score (unadjusted): (*P* = 0.561)

Table 33. Summary of studies on the relationship between health literacy and mortality

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Baker et al., 2007[38] (Analysis 1) Baker et al., 2008[40] (Analysis 2) (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Howard et al., 2006;[36] Wolf et al., 2005;[39] Howard et al., 2005;[41] Baker et al., 2004[35]) Prospective cohort N = 3,260 Good	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA Inadequate: 24% Marginal: 11% Adequate: 64%	Baseline measures: • Number of chronic conditions • Physical health score • Mental health score • IADL limitation • ADL limitation • Smoking • Alcohol use • Vigorous physical activity • BMI	All-cause mortality rate Inadequate: 39% Marginal: 29% Adequate: 19% Cardiovascular mortality rate: Inadequate: 19% Marginal: 17% Adequate: 8% Cancer mortality rate Inadequate: 9% Marginal: 5% Adequate: 6% Non-cardiovascular/non-cancer mortality rate Inadequate: 11% Marginal: 7% Adequate: 5%	Analysis 1 All-cause mortality Inadequate group had a greater rate than adequate group (adjusted) (HR,1.52; 95%CI, 1.26-1.83) No difference between marginal and adequate groups (adjusted) (HR, 1.13; 95%CI, 0.90-1.41) Cardiovascular mortality Inadequate group had a greater rate than the adequate group (adjusted) (HR, 1.52; 95%CI, 1.16-2.00) Marginal group had a greater rate than the adequate group (adjusted) (HR, 1.39; 95%CI, 1.02-1.90) Cancer mortality No difference between inadequate and adequate groups (adjusted) (HR, 1.18; 95% CI, 0.81-1.72) No difference between marginal and adequate groups (adjusted) (HR, 0.65; 95% CI, 0.38-1.09) All other causes mortality Inadequate group has a greater rate than the adequate group (adjusted) (HR = 1.87; 95% CI, 1.32-2.67

ADL, activities of daily living; AQLQ, Asthma Quality of Life Questionnaire; BMI, body mass index; FACT-G, Functional Assessment of Cancer Therapy-General; HR, Hazard ratio; HR, hazard ratio; HRQoL, health-related quality of life; IADL, Instrumental activities of daily living; NAAL, National Assessment of Adult Literacy; NALS, National Adult Literacy Survey; OR, Odds ratio; PCS, Physical Component Summary; SF, short form; VRQoL, vision-related quality of life.

Table 33. Summary of studies on the relationship between health literacy and mortality (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Baker et al., 2007[38] (Analysis 1) Baker et al., 2008[40] (Analysis 2) (continued)				No difference between marginal and adequate groups (adjusted) (HR = 1.18; 95% CI, 0.76-1.85) Analysis 2 All cause mortality (adjusted for all confounders and level of cognitive functioning) Inadequate group has a greater rate than adequate (adjusted) (HR, 1.27; 95% CI, 1.03-1.57) No difference between marginal and adequate group (adjusted) (HR, 1.08; 95% CI, 0.85-1.36)
Sudore et al., 2006[95] (companion: Sudore et al., 2006[96]) Prospective cohort, retrospective analysis N = 2,512 Good	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM Limited: 24% Adequate: 76%	• Demographics: (age, race, gender, income, education) • Health status: (self-rated health, cardiac disease, stroke, cancer, hypertension, diabetes, obesity) • Health-related behaviors: (former or current smoker, drinking >1 alcoholic beverage per day) • Poor health care access: (lack of a regular doc or clinic, no flu shot within past 12 months, no insurance for medications) • Psychosocial status: (high depressive symptoms, poor personal mastery)	Mortality Rate Limited: 20% Adequate: 11%	Limited group greater odds of dying than adequate group (adjusted) (HR, 1.75, 95%CI, 1.27 to 2.41) Limited group greater odds of dying than adequate group (adjusted, excluding participants with cognitive impairment) (HR, 1.94, 95%CI, 1.37 to 2.74)

Table 34. Summary of studies of the relationship between health literacy and costs (KQ 1c)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Howard, et al., 2005[41] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 2007;[38] Howard et al., 2006;[36] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Prospective cohort N = 3,260 S-TOFHLA Good	New Medicare managed-care enrollees in Cleveland, Houston, Tampa, and south Florida S-TOFHLA Inadequate: 25% Marginal: 11% Adequate: 64%	• Age • Sex • Race/ethnicity • Income • Education • Tobacco • Alcohol consumption • Self-reported comorbid conditions	Costs 1 year period Overall: mean (SD) Inadequate: $9614 ± $22536 Marginal: $8484 ± $16646 Adequate: $7246 ± $17 941 Inpatient: mean (SD) Inadequate: $6817 ± $21049 Marginal: $5857 ± $15240 Adequate: $4656 ± $16 428 Outpatient: mean (SD) Inadequate: $1970 ± $3477 Marginal: $1727 ± $2954 Adequate: $1805 ± $3188 Emergency Department: mean (SD) Inadequate: $189 ± $551 Marginal: $182 ± $593 Adequate: $100 ± $360 Pharmacy: mean (SD) Inadequate: $638 ± $1267 Marginal: $719 ± $998 Adequate: $684 ± $890	Overall costs (adjusted) No difference between Inadequate and adequate groups (β = $1551; 95% CI, -$166-$3267) No difference between marginal and adequate groups (β = $596; 95%CI, -$1437-$2630) Inpatient costs (adjusted) No difference between inadequate and adequate groups (β = $1543; 95%CI, -$89-$3175 No difference between marginal and adequate groups (β = $748; 95%CI, -$1252-$2748 Outpatient costs (adjusted) No difference between inadequate and adequate groups (β = -$213; 95%CI, -$481-$55) Costs lower in marginal group (β = -$350; 95%CI, -$679- -$20) ED costs (adjusted) Higher costs in inadequate group (β = $108; 95%CI, $62-$154) Higher costs in marginal group (β = $80; 95%CI, $28-$132) Pharmacy costs (adjusted) No difference between inadequate and adequate group (β = $27; 95%CI, -$55-$110) No difference between marginal and adequate groups (β = $35; 95%CI, -$62-$132)

CI, confidence interval; ED, emergency department; IDR, Instrument for the Diagnosis of Reading; N, number; S-TOFHLA, short form Test of Functional Health Literacy in Adults; SD, standard deviation;

Table 34. Summary of studies of the relationship between health literacy and costs (KQ 1c) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Weiss et al. 2004[102] Retrospective cohort N = 74 Fair	Medicaid beneficiaries in Arizona IDR Low: 24% Higher: 76%	• Age • Ethnic group • Health status	Total costs, 1 year period, mean (range) Low: $10,688 ($0 - $95,002) Higher: $2,890 ($0 - 38,957)	Medicaid costs over a 1 year period higher in low group (adjusted) (*P* = 0.037)

Table 35. Summary of studies of the relationship between health literacy and disparities (KQ 1d)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Sentell and Halpin, 2006[92] Cross-sectional N = 23,889 Fair	National sample of adults Total NALS score • Level 1: 20% • Level 2: 27% • Level 3: 34% • Level 4: 18% • Level 5: 2%	• Race • Education • Understand English • Born in U.S.A. • Unemployed • Family income • Income missing • Sex • Age • Married • Get food stamps • Live in Metropolitan Statistical Area • Region	Self report of physical, mental, or other health condition that keeps respondent from working Data: NR Long-term illness (greater than 6 months) Data: NR	Health literacy mediates the association of black race on having a condition that keeps you from work (adjusted): Odds associated with black race, not controlling for health literacy: OR 1.54, 95% CI, 1.29-1.84 Odds associated with black race, controlling for health literacy: OR 1.04; 95% CI, 0.85-1.26 Health literacy mediates the effect of black race on having long-term illness (adjusted) Odds associated with black race, not controlling for health literacy: OR 1.24; 95% CI, 1.03-1.49 Odds associated with black race, controlling for health literacy: OR, 1.07; 95% CI, 0.89-1.30

CI, confidence interval; HIV, human immunodeficiency virus; HR, hazard ratio; HRQoL, health related quality of life; N, number; NAAL, National Assessment of Adult Literacy; NALS, National Adult Literacy Survey; NR, not reported; NS, not sufficient; OR, odds ratio; PSA, prostate-specific antigen; REALM, Rapid Estimate of Adult Literacy in Medicine; SE, standard error; SF-12, Short Form 12; S-TOFHLA, short form Test of Functional Health Literacy in Adults; U.S.A, United States of America.

Table 35. Summary of studies of the relationship between health literacy and disparities (KQ 1d) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Howard, 2006[36] (companion: Gazmararian, 2006;[34] Wolf et al., 2007;[37] Baker et al., 2007;[38] Wolf et al., 2005;[39] Baker et al., 2008;[40] Howard et al., 2005;[41] Baker et al., 2004[35]) Cohort N = 3,260 Fair	New Prudential Medicare managed care enrollees in Cleveland, Ohio, Houston, Texas, Tampa, and south Florida (including Ft. Lauderdale and Miami) S-TOFHLA • by race: • White - • Adequate: 71% • Marginal: 10% • Inadequate: 19% • Black - • Adequate: 36% • Marginal: 12% • Inadequate: 52%	• Age • Gender • Race/ethnicity • Education • Income • Site • Morbidity • Smoker	Physical HRQoL mean (SF-12) White: 44.9 Black: 43.6 Mental HRQoL mean (SF-12) White: 55.7 Black: 53.0 Self-reported health good or higher White: 0.39 Black: 0.23 Receipt of influenza vaccine White: 0.826 Black: 0.701 Receipt of pneumococcal vaccine White: 0.48 Black: 0.29	Physical HRQoL (difference in scores between white and black, adjusted) Not controlling for health literacy: 0.1 Controlling for health literacy: -0.5 Difference between models: (0.6, 95% CI, 0.3-0.9) Mental HRQoL (difference in scores between white and black, adjusted) Not controlling for health literacy: 0.5 Controlling for health literacy: 0.2 Difference between models: (0.3, 95% CI, 0.1-0.5) Self-reported health good or higher (difference in scores between white and black, adjusted) Not controlling for health literacy: 0.8 Controlling for health literacy: 0.6
Wolf et al., 2006[104] Convenience N = 308 Good	Patients with newly diagnosed prostate cancer in 4 outpatient oncology and urology clinics in Chicago area REALM Low: 18% Marginal: 33% Functional: 50%	• Age • Race • Annual income • Marital status	PSA Level > 20 ng/mL Marginal: 24% Low: 33% Functional: 14% Outcomes by race: NR	Health literacy mediates the association between race (African American versus white) and PSA level (adjusted). Odds associated with African American, not controlling for health literacy (OR, 4.6; 95% CI, 2.0- 9.5) Odds associated with African American, controlling for health literacy (OR, 3.0; 95% CI, 0.8- 9.1)
Bennett et al., 2009[50] (companion: White et al. 2008[103]) Cross-sectional N = 2,668 Good	65 from a nationally representative sample of U.S. population NAAL Below Basic: 29.0% Basic: 29.5% Intermediate: 38.2 Proficient 3.3%	• Race • Income • Gender • Age • Nativity	NR	Mediation effect of health literacy on relationship between race/ethnicity and self-reported health status (adjusted, comparison is white)

Table 35. Summary of studies of the relationship between health literacy and disparities (KQ 1d) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Bennett et al., 2009[50] (companion: White et al. 2008[103]) (continued)				Odds associated with black race, • not controlling for health literacy (β = -0.34 (SE 0.11) (*P* < 0.05)) • controlling for health literacy (β = -0.24 (SE 0.04) (*P* < 0.05)) Odds associated with Hispanic, • not controlling for health literacy (β = 0.02 (SE 0.14) (*P* = NS)) • controlling for health literacy (β = 0.21 (SE 0.07) (*P* < 0.05)) Mediation effect of health literacy on relationship between race/ethnicity and receipt of influenza vaccine (adjusted, comparison is white) Odds associated with black race, • not controlling for health literacy (β = -0.24 (SE 0.10) (*P* < 0.05)) • controlling for health literacy (β = -0.18 (SE 0.04) (*P* < 0.05)) Odds associated with Hispanic, • not controlling for health literacy (β = -0.04 (SE 0.16) (*P* = NS)) • controlling for health literacy (β = 0.08 (SE 0.07) (*P* = NS)) Mediation effect of health literacy on relationship between race/ethnicity and receipt of mammogram (adjusted, comparison is white)

Table 35. Summary of studies of the relationship between health literacy and disparities (KQ 1d) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Bennett et al., 2009[50] (companion: White et al. 2008[103]) (continued)				Odds associated with black race, • not controlling for health literacy (β = 0.23 (SE 0.15) (*P* =NS)) • controlling for health literacy (β = 0.28 (SE 0.06) (*P* < 0.05)) Odds associated with Hispanic, • not controlling for health literacy (β = 0.57 (SE 0.19) (*P* < 0.05)) • controlling for health literacy (β = 0.70 (SE 0.07) (*P* < 0.05)) Mediation effect of health literacy on relationship between race/ethnicity and dental checkup (adjusted, comparison is white) Odds associated with black race, • not controlling for health literacy (β = -0.13 (SE 0.11) (*P* =NS)) • controlling for health literacy (β = -0.04 (SE 0.04) (*P* = NS)) Odds associated with Hispanic, • not controlling for health literacy (β = 0.19 (SE 0.14) (*P* = NS)) • controlling for health literacy (β = 0.35 (SE 0.05) (*P* < 0.05))

Table 35. Summary of studies of the relationship between health literacy and disparities (KQ 1d) (continued)

Authors, Year, Study Design, Analysis Sample Size, Quality	Population by Health Literacy Level and Setting	Potential Confounders Controlled in Analysis	Outcome Measure Outcomes By Health Literacy Level	Differences in Results Between Health Literacy Levels
Osborn et al., 2007[42] (companions: Wolf et al., 2007;[43] Waite et al., 2008[44]) Cross-sectional N = 204 Fair	Patients at 2 HIV clinics, 1 in Chicago, Illinois and 1 in Shreveport, Louisiana REALM Low: 11% Marginal: 20% Adequate: 69%	• Race • Gender • Age • Income • Number of medications in HIV regimen • Non-HIV comorbid conditions • Mental illness	Non-adherence to HIV medications in past 4 days Low: 52% Marginal: 19% Adequate: 30%	Health literacy medicates the association of black race on adherence (adjusted) Odds associated with black race, not controlling for health literacy OR, 2.4, 95% CI, 1.14 - 5.08 Odds associated with black race, controlling for health literacy OR, 1.8, 95% CI, 0.51 - 5.85
Sudore et al., 2006[95] (companion: Sudore et al., 2006[96]) Prospective cohort, retrospective analysis N = 2,512 Good	Seniors (70-79 year old) in Pittsburgh, Pennsylvania and Memphis, Tennessee REALM Limited: 24% Adequate: 76%		Mortality Rate Limited: 20% Adequate: 11%	Mortality within subgroups comparing limited group with adequate: Interaction between race and health literacy not significant) White: (HR 2.36; 95% CI, 1.63-3.42) Black: (HR 1.66; 95% CI, 1.29-2.29)

Table 36. The relationship between numeracy level and use of health care services

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Aggarwal et al., 2007[122] Cross-Sectional Survey N = 264 *Note: sample for actual colon screening 152 (b/c excluded women < age 50 who would not be eligible for screening) Fair	74% Inadequate Numeracy on 5-item numeracy test adapted from Black and Toteson	% with Up-to-date breast cancer screening % with Up-to-date colon cancer screening	• Age • Race • Education • Primary care provider • FH disease	Up-to-date with screening for breast CA: Inadequate: 71% Adequate: 77% Up-to-date with colon CA guidelines: Inadequate: 46% Adequate: 51%	OR for Up-to-date breast cancer screening (inadeq. vs. adeq.): OR, 1.43 (0.62-3.33)[a] OR for up-to-date colon cancer screening (inadeq. vs. adeq.): OR, 0.91 (0.3-2.0)[a]
Hibbard et al., 2007[62] RCT However, results of interest in this paper are cross-sectional Fair	43% Low Numeracy (less than mean = 9 on 15-item scale adapted from Lipkus)	% Choosing higher quality hospital	None	Choice of Higher Quality Hospital: Low numeracy: 59.9% High numeracy: 71.7% Note: interaction by patient activation (i.e., motivation to engage with material): Low numeracy: Low activation: 53% High activation: 66.8% P for interaction: ($P < 0.05$) High numeracy: Low activation: 66.3% High activation: 77% P for interaction: ($P < 0.001$)	Absolute difference in choice of higher quality hospital (high vs. low, unadjusted): -11.8%[a], ($P < 0.01$)

[a]Calculated by research team
b/c, because; FH, family history; CA, cancer; OR, odds ratio; inadeq., inadequate; vs., versus; adeq., adequate; RCT, randomized controlled trial; i.e., example

Table 37. The relationship between numeracy level and accuracy of risk perception

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy levels	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference by Numeracy Level
Davids et al., 2004[119] Cross-Sectional N = 254 Note: 18% of those invited Fair	% of questions correct on numeracy test adapted from Schwartz and Woloshin: 0 correct: 15% 1 correct: 17% 2 correct: 27% 3 correct: 41%	Estimation Error For Breast Cancer Risk (Absolute difference between perceived and Gail model calculated breast cancer risks over lifetime and 5-years)	Age, Race, Education, Income, FH breast cancer, Age at menses, Age at first live birth, # of breast biopsies	Lifetime Risk Estimation Error: Numeracy Score: 0 correct: 40.1 1 correct: 28.3 2 correct: 30.1 3 correct: 25.8 5-Year Estimation Error: Numeracy Score: 0 correct: 32.2 1 correct: 24.0 2 correct: 27.8 3 correct: 20.5	Lifetime Risk Estimation Error (adjusted): Beta-coefficient for every additional numeracy question incorrect: 0.18, 95% CI, 0.05-0.30[a] 5-year Risk Estimation Error (adjusted): NR Note: unadjusted correlation NS
Haggstrom and Schapira, 2006[120] Cross-Sectional N = 207 Note: 18% of those invited Fair	NR % with less than 3 correct on Schwartz and Woloshin numeracy test	Accurate Perception of Breast Cancer Survival (compared with 5-yr survival rates) Accurate Perception of Screening Mammography Benefit (compared with meta-analysis results)	Age, Race, FH, Family income, Insurance, Education	NR	Accurate perception of Breast Cancer Survival over 5 years (0-2 questions vs. 3 correct; adjusted): OR, 1.19; 95% CI, 0.54–2.63[a] Accurate perception of Screening Mammography Benefit (0-2 correct vs. 3 correct; adjusted): OR, 1.33; 95% CI, 0.50–3.57[a]
Sheridan and Pignone, 2002[116] RCT Relevant data analyzed cross-sectionally N = 62 medical students Fair	% of questions correct on numeracy test from Schwartz and Woloshin 0-1 correct: 5% 2 correct: 18% 3 correct: 77%	ability to correctly compare treatment benefit presented alternately as ARR, RRR, NNT, combination ability to correctly calculate treatment benefit presented alternately as ARR, RRR, NNT, combination	None	Correctly stated which treatment provided more benefit: 0-1 correct: 33% 2 correct: 91% 3 correct: 94% Correctly calculated treatment benefit: 0-1 correct: 0% 2 correct: 36% 3 correct: 71%	Correctly stated which treatment provided more benefit: 0-1 vs. 3 correct (unadjusted): - 61%[a], (P = 0.03) Correctly calculated treatment benefit (unadjusted): 0-1 vs. 3 correct: -71%[a], (P < 0.01)

[a]Calculated by research team
5-yr survival rate, 5-year survival rates;ARR, absolute risk reduction; ARR, absolute risk reduction; CI, confidence interval; CI, confidence interval; NNT, number needed to treat; NNT, number needed to treat.; NR, not reported; NS, not significant; OR, odds ratio; OR, odds ratio; RCT, randomized controlled trial; RCT, randomized controlled trial; RRR, relative risk ratio. FH, family history; RRR, relative risk reduction; vs., versus.

Table 37. The relationship between numeracy level and accuracy of risk perception **(continued)**

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy levels	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference by Numeracy Level
Sheridan et al., 2003[117] RCT Relevant data analyzed cross-sectionally N = 357 Fair	% of questions correct on numeracy test from Schwartz and Woloshin 0 correct: 41% 1 correct: 30% 2 correct: 27% 3 correct: 2%	ability to correctly compare treatment benefit presented alternately as ARR, RRR, NNT, combination ability to correctly calculate treatment benefit presented alternately as ARR, RRR, NNT, combination	None	Correctly stated which treatment provided more benefit: 0-1 correct: 35% 2 correct: 63% 3 correct: 88% Correctly calculated treatment benefit: 0-1 correct: 5% 2 correct: 30% 3 correct: 50%	Correctly stated which treatment provided more benefit: 0-1 vs. 3 correct (unadjusted): - 53%[a], ($P < 0.001$) Correctly calculated treatment benefit (unadjusted): 0-1 vs. 3 correct: -45%[a], ($P < 0.001$)
Schwartz et al., 1997[23] RCT Relevant data analyzed cross-sectionally N = 287 Fair	% of questions correct on numeracy test from Schwartz and Woloshin 0 correct: 30% 1 correct: 28% 2 correct: 26% 3 correct : 16%	Ability to correctly perceive treatment benefit presented alternately as ARR +/- baseline risk or as RRR +/- baseline risk	Age, Income, Education, Frame of information	Correctly perceived treatment benefit: 0 correct: 5.8% 1 correct: 8.9% 2 correct: 23.7 % 3 correct: 40%	Correctly perceived treatment benefit: 0 vs. 1 correct (adjusted): absolute difference: -3.1%[a] OR, 0.77; 95% CI, 0.21–3.33[a] 0 vs. 2 correct (adjusted): absolute difference: -17.9% [a] OR, 0.14; 95% CI, 0.04-0.45[a] 0 vs. 3 correct (adjusted): absolute difference: +34.2%[a] OR, 0.08; 95% CI, 0.02-0.28[a]

Table 38. Relationship between numeracy level and knowledge

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy levels	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Cavanaugh et al., 2008[118] Cross-Sectional N = 398 Fair	**WRAT-3, numeracy:** < 9th grade: 69% ≥ 9th grade: 31% **Diabetes Numeracy Test (DNT: median % correct):** Overall : 65% Quartile 1: 27% Quartile 2: 25% Quartile 3: 26% Quartile 4: 23%	Median Diabetes knowledge (score range 0-100)	None	Median Diabetes knowledge: DNT Quartile 1: 52 DNT Quartile 2: 65 DNT Quartile 3: 79 DNT Quartile 4: 86	Median diabetes knowledge: DNT Quartile 1 vs. 4 (unadjusted): -34[a], P for trend: (*P* < 0.001)
Vavrus, 2006[121] Cross-Sectional N = 277 Fair	57% Low Numeracy (correctly completed 0-1 of 3 calculations on numeracy test NOS)	% of 5 Knowledge Questions about general health correctly answered % of 5 Knowledge questions about HIV/AIDS correctly answered	Gender, Literacy, Household spending, Parents education, Television in home, Siblings, Electricity, Sewage	NR	OR for high general health knowledge (low vs. high numeracy, adjusted): 0.66[a], (*P* > 0.05) OR for high HIV/AIDS knowledge (low vs. high numeracy, adjusted): 0.36[a], (*P* < 0.001)
Aggarwal et al., 2007[122] Cross-Sectional N = 264 *Note: sample for actual colon screening 152 (b/c excluded women < age 50 who would not be eligible for screening) Fair	74% Inadequate Numeracy on 5-item numeracy test adapted from Black and Toteson	Knowledge of breast cancer and colorectal cancer screening guidelines	Age, Race, Education, Primary Care Provider, FH of disease	Knowledge of breast CA guideline: Inadequate: 25% Adequate: 48% Knowledge of colon CA guidelines: Inadequate: 17% Adequate: 35%	Knowledge of breast CA guidelines (inadeq. vs. adeq., adjusted): 0.37 (0.19- 0.71)[a] Knowledge of Colon Cancer guideline (inadeq. vs. adeq., adjusted): 0.63 (0.29 – 1.25)[a]

[a]Calculated by research team

adeq., adequate; b/c, because; CA, cancer; CI, confidence interval; DNT, Diabetes Numeracy Test; FH, family history; HIV/AIDS, acquired immunodeficiency syndrome/human immunodeficiency virus; inadeq., inadequate; NOS, not otherwise specified; NR, not reported; OR, odds ratio; SES, socioeconomic status; TOFHLA, Test of Functional Health Literacy in Adults; vs., versus; WRAT-3, Wide Range Achievement Test-3rd edition.

Table 38. Relationship between numeracy level and knowledge (continued)

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy levels	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Yin et al., 2007[106] Cross-Sectional N = 292 caregivers of young children Fair	NR by TOFHLA, numeracy (split at median)	% of Caregivers with poor knowledge of weight based-dosing	Caregiver Education, Country of origin, Language, SES; Age of children; Regular healthcare provider; Experience in healthcare setting	Poor knowledge of weight based dosing: innumerate: 76% Numerate: 62%	Odds of poor knowledge of weight based dosing (innumerate vs. numerate, adjusted): 1.1; 95% CI, 0.6-2.2 Note: when education, acculturation, and SES are not included in model, result was significant (1.8; 95% CI, 1- 3.1)

Table 39. Relationship between numeracy and self-efficacy

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Cavanaugh et al., 2008[118] Cross-Sectional N = 398 Fair	**WRAT-3, numeracy:** < 9th grade: 69% ≥ 9th grade: 31% **Diabetes Numeracy Test (DNT: median % correct):** Overall : 65% Quartile 1: 27% Quartile 2: 25% Quartile 3: 26% Quartile 4: 23%	Median Self-efficacy for diabetes self-management Measured by Perceived Diabetes Self-Management Scale (score range 8-40)	None	Median Self-efficacy: DNT Quartile 1: 28 DNT Quartile 2: 28 DNT Quartile 3: 31 DNT Quartile 4: 32	Median Self-efficacy: DNT Quartile 1 vs. 4: -4[a], *P* for trend: (*P* = 0.003)

[a]Calculated by research team|
DNT, Diabetes Numeracy Test; vs., versus; WRAT-3, Wide Range Achievement Test-3rd edition.

Table 40. Relationship between numeracy level and behavior

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy	Outcome	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Cavanaugh et al., 2008[118] Cross-Sectional N = 398 Fair	WRAT-3, numeracy: < 9th grade: 69% ≥ 9th grade: 31% Diabetes Numeracy Test (DNT: median % correct): Overall : 65% Quartile 1: 27% Quartile 2: 25% Quartile 3: 26% Quartile 4: 23%	Median Reported Use of Self-management behaviors using the Summary of Diabetes Self-Care Activities scale (score range 0-7) Includes the following behaviors: • General diet • Specific diet • Exercise • Blood glucose level testing • Foot care	None	Self-management behaviors: General diet: Quartile 1: 5 Quartile 4: 5 Specific diet: Quartile 1: 3.5 Quartile 4: 3.5 Exercise: Quartile 1: 3.5 Quartile 4: 2.75 Blood glucose level testing Quartile 1: 7 Quartile 4: 6.5 Foot care Quartile 1: 5.5 Quartile 4: 3.25	Absolute difference in general diet behaviors (Quartile 1 vs. 4): 0[a], (*P* = 0.21) Absolute difference in specific diet behaviors (Quartile 1 vs. 4): 0[a], (*P* = 0.82) Absolute difference in exercise behavior (Quartile 1 vs. 4): +0.75[a], (*P* = 0.25) Absolute difference in blood glucose level testing (Quartile 1 vs. 4): 1.5[a], (*P* = 0.44) Absolute difference in foot care behavior (Quartile 1 vs. 4): 2.25[a], (*P* < 0.001)

[a]Calculated by research team
DNT, Diabetes Numeracy Test; vs., versus; WRAT-3, Wide Range Achievement Test- 3rd edition.

Table 41. Relationship between numeracy level and skills

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy	Outcomes	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Estrada et al., 2004[54] Prospect Cohort N = 143 Note: 11 were proxies for patients Fair	6-items (including 3 adapted from Schwartz and Woloshin): 0 correct: 13.3% 1-2 correct: 35% 3-4 correct: 34.3% 5-6 correct: 17.5%	Correct Medication Dosing operationalized as: % INR tests within the therapeutic range INR variability (using sigma, a composite capturing # of measurements, time since previous measure, and therapeutic range; higher values are worse)	Age	% INR tests within range: 0 correct: 56% 5-6 correct: 66% INR variability using mean sigma score: 0 correct: 0.80 5-6 correct: 0.45	Absolute difference in % INR tests within range (adjusted): NR, (*P* = 0.35) Absolute difference in INR variability (adjusted): NR, (*P* = 0.03)
Yin et al.,2007[106] Cross-Sectional N = 292 caregivers of young children Fair	NR by TOFHLA, numeracy (split at median)	% of Caregivers with poor knowledge of correct medication dosing instrument (operationalized as reported use of non-standardized instrument)	Caregiver Education, Country of origin, Language, SES; Age of children; Regular healthcare provider; Experience in healthcare setting	Use of non-standardized dosing instrument: Innumerate: 34% numerate: 19%	Odds of use of non-standardized dosing instrument: (innumerate vs. numerate, fully adjusted) 1.4; 95% CI, 0.8-2.7 Note: when education, acculturation, and SES are not included in model, result was significant (1.9; 95% CI, 1.1-3.4)
Rothman et al., 2006[8] Cross-Sectional N = 200 Fair	63% < HS on WRAT-3, numeracy	% questions correct on 24-item Nutrition Label Survey after being given a nutrition label to read	Age, Gender, Race, Insurance, Income, Education, Clinical Disease, Specific diet, Label reading frequency	Nutrition Label Comprehension: < high school: 61% ≥ high school: 84%	Absolute difference in NLS score (adjusted): NR, (*P* < 0.001)

[a]Calculated by research team

CI, confidence interval; HS, high school; i.e., example; INR, international normalized ratio; NLS, Nutrition Label Survey; NR, not reported; NS, not significant; RCT, randomized controlled trial; SES, socioeconomic status; TOFHLA, Test of Functional Health Literacy in Adults; vs., versus; WRAT-3, Wide Range Achievement Test-3rd edition.

Table 41. Relationship between numeracy level and skills (continued)

Author, Year, Study Design, Sample Size, Quality	% Low Numeracy	Outcomes	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Hibbard et al., 2007[62] RCT However, results of interest in this paper are cross-sectional N = 303 Fair	43% Low Numeracy (less than mean = 9 on 15-item scale adapted from Lipkus)	% questions correct on 13-item health plan knowledge questionnaire after being given health plan information to review	None	Health Plan Comprehension: Low numeracy: 72%[a] High numeracy: 90.5%[a] Note: interaction by patient activation (i.e., motivation to engage with material): Low numeracy: Low activation: 67.7% High activation: 76.3% P for interaction: ($P < 0.05$) High numeracy: Low activation: 90.2% High activation: 90.7% P for interaction: NS	Absolute difference in comprehension (low vs. high, unadjusted): -18.5%[a], ($P < 0.05$)

Table 42. Relationship between numeracy level and disease prevalence and severity

Author, Year, Study Design, Sample Size Quality	% Low Numeracy	Outcomes	Potential Confounders Adjusted for in Analysis	Results by Numeracy Level	Difference
Huizinga et al., 2008[65] Cross-Sectional N = 169 Fair	WRAT-3, numeracy < 9th grade: 66% ≥ 9th grade: 34%	Mean BMI	Age, Gender, Race, Income, Education, REALM	Mean BMI < 9th grade: 31.8 ≥ 9th grade: 27.9	BMI (< 9th grade vs. ≥ 9th grade, unadjusted): +3.9[a], (*P* = 0.008) Effect of numeracy on BMI: (adjusted): β = -0.14, (*P* = 0.01)
Cavanaugh et al., 2008[118] Cross-Sectional N = 398 Fair	**WRAT-3, numeracy:** < 9th grade: 69% ≥ 9th grade: 31% **Diabetes Numeracy Test (DNT: median % correct):** Overall: 65% Quartile 1: 27% Quartile 2: 25% Quartile 3: 26% Quartile 4: 23%	Median HbA1c	Age, Gender, Race, Income, Type of diabetes, Years since diagnosis of diabetes, Clinic Site	Median HbA1c Quartile 1: 7.6% Quartile 2: 7.1% Quartile 3: 7.1% Quartile 4: 7.1%	Absolute difference in Median HbA1c (quartile 1 vs. 4: +0.5%, (*P* = 0.119) In adjusted analysis, every 10% decrease in % correct DNT questions resulted in an increase in HbA1c of 0.09% (95% CI, 0.01%-0.16%)
Rothman et al., 2006[8] Cross-Sectional N = 200 Fair	63% < HS on WRAT-3, numeracy	% with self-reported illness requiring dietary restriction % BMI > 30	None	Illness requiring dietary restriction: < HS: 44% ≥ HS: 35% % BMI > 30: < HS: 48% ≥ HS: 40%	Absolute difference in percent with illness requiring diet restriction (< HS vs. ≥ HS, unadjusted): +9%, (*P* = 0.20) Absolute difference in % with BMI > 30 (< HS vs. ≥ HS, unadjusted): +8%, (*P* = 0.30)

[a]Calculated by research team

BMI, body mass index; CI, confidence interval; DNT, Diabetes Numeracy Test; HbA1c, glycosylated hemoglobin; HS, high school; REALM, Rapid Estimate of Adult Literacy in Medicine; vs., versus;WRAT-3, Wide Range Achievement Test-3rd edition.

Chapter 4. The Effect of Interventions to Mitigate the Effects of Low Health Literacy

Introduction

This chapter presents the results of our literature search for Key Question 2. The analytic framework for this question is presented in Chapter 2. In brief, Key Question 2 asked what are effective interventions to mitigate the effects of low health literacy on a) use of health care services, b) health outcomes, c) the costs of health care, and d) health disparities?

For KQ 2, we present our results in two ways. First, where interventions use single strategies to mitigate the effects of low health literacy, we present results by intervention strategy (e.g., alternative document design, alternative numerical presentation, additive or alternative pictorial representation, alternative media, alternative readability and document design) in an effort to aid intervention developers. The majority of results in this section focus on comprehension following the intervention, although a few[123,124] also focus on the use of health care services. Second, where interventions use multiple strategies (preventing conclusions about the active intervention components), we organize results in accordance with outcomes in our analytic framework.

Tables presenting selected information about KQ 2 studies are embedded within or presented at the end of the chapter and detailed evidence tables appear in Appendix D. Tables 43 through 45 called out below, contain the aggregate strength of evidence grades based on the studies included in the update to answer KQ 2. Chapter 2 described the methods for arriving at strength of evidence grades; Appendix E gives the domain-specific scores used in deriving the overall grades. We provide grades for particular outcomes and types of interventions. To reiterate, the definitions of the overall strength-of-evidence grades are as follows:

- 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.
- Insufficient: Evidence either is unavailable or does not permit estimation of an effect.

Additionally, we provide insights based on observations about the common features of effective interventions. These “cross-cutting” observations are presented at the end of the chapter.

Because this report is an update, we needed to integrate findings from our first review in 2004 with those of our current review. To do this, we reorganized findings from the first review using the organizational structure described above and note in each section how results from the first review are similar or different than current findings and whether these results modify our current conclusions.

Table 43. KQ 2 single intervention studies: strength of evidence grade by design feature

Design Feature	Number of Studies	Results	Overall Grade
Alternative Document Design	2 RCTs examining multiple simplifications	Highlighting common features (n=1): No effect Chunking advantages/disadvantages (n=1): improved comprehension for high literacy, worsened comprehension for low literacy if long rather than short list Essential info only (n=1): Improved comprehension and choice of higher quality plans Essential info first (n=1): Improved comprehension for low literacy only. No effect on health plan choice.	Low
Alternative Numerical Presentation	1 RCT examining higher number (vs. lower number) better	Higher (vs. lower) number better (n=1): Improved comprehension and choices of higher quality options for low (but not high) numeracy individuals	Insufficient
Alternative Pictorial Representations	4 RCTs and 2 quasi-experimental studies examining (1) adding symbols to numerical information, (2) adding illustrations to prose, (3) using different pictorial representations for same concept	Adding symbols to numerical info (n=2): Mixed effects. No effect if higher number better. Poorer choices in high numeracy individuals if lower number better. No effect on comprehension, but better choices, if accompanying essential information. Poorer choices for lower numeracy participants if accompanying non-essential information. Adding illustrations to prose (n=2): No effect of mind map added to brochure or illustrations added to simple medication label text Using different pictorial representations for the same concept (n=2): Improvements with grouped (versus random) pictograms (n = 1) and with some teratogen warning symbols	Low
Alternative Media	1 RCT examining standard print, simplified print, video, computerized material	No effect of any alternative format on free recall. Trends toward improved prompted recall for all individuals receiving computerized material and for low literacy individuals receiving simplified print	Low
Alternative Readability and Document Design	3 RCTs and 1 quasi-experimental study with post-only data	Mixed	Low
Physician Notification of Patient Literacy Status	1 cRCT	No effect on patient level outcomes	Low

cRCT, cluster randomized controlled trial; info, information; RCTs, randomized controlled trials; vs., versus.

Table 44. KQ 2 mixed intervention studies: strength of evidence grades by type of outcome

Outcome	Number of Studies	Results	Overall Grade
Use of health care services	4 RCTs, 1cRCT, and 1 quasi-experimental study	Preventive services (n=2): Increased use across literacy levels ED visits (n=2): Reduced use across literacy levels Hospitalizations (n=3): Reduced use (or trends toward reduced use) across literacy levels; greater reductions in low literacy population	Moderate across all categories of health services use combined
Disease prevalence and severity	4 RCTs, 3 quasi-experimental studies	Self-management programs (n=3): mixed effects on biomarkers depending on study quality Disease management programs (n=2): improved HbA1c in low literacy group, improved BP across literacy levels Adult Basic and Literacy Education (n=1): improved depression severity across literacy levels	Self-management programs: Low Disease management programs: Moderate Adult Basic and Literacy Education: Low
Knowledge	3 RCTs and 6 quasi-experimental studies	Mixed results	Low
Self Efficacy	4 RCTs and 5 quasi-experimental studies	Mixed results depending on intensity of intervention; positive effect across literacy levels for intensive interventions	Low
Behavior	2 RCTs and 1 quasi-experimental study	Improved self-management behaviors, greater improvement in adequate literacy group	Moderate
Adherence	2 RCTs and 2 quasi-experimental studies (1 with post-test only data)	Mixed results related to the intensity of the intervention and measure of adherence	Low
Quality of Life	4 RCTs (1 measured QoL only post-test in intervention group)	Mixed results	Low
Costs	1 RCT	Nonsignificant trend toward reduced cost across literacy groups	Low

BP, blood pressure; cRCT, cluster randomized controlled trial; ED, emergency department; HbA1c, glycosylated hemoglobin; QoL, quality of life; RCT, randomized controlled trial.

Table 45. KQ 2 mixed intervention studies: strength of evidence grades by type of outcome

Outcome	Number of Studies	Results	Overall Grade
Use of health care services	4 RCTs, 1cRCT, and 1 quasi-experimental study	Preventive services (n=2): Increased use across literacy levels ED visits (n=2): Reduced use across literacy levels Hospitalizations (n=3): Reduced use (or trends toward reduced use) across literacy levels; greater reductions in low literacy population	Moderate across all categories of health services use combined
Disease prevalence and severity	4 RCTs, 3 quasi-experimental studies	Self-management programs (n=3): mixed effects on biomarkers depending on study quality Disease management programs (n=2): improved HbA1c in low literacy group, improved BP across literacy levels Adult Basic and Literacy Education (n=1): improved depression severity across literacy levels	Self-management programs: Low Disease management programs: Moderate Adult Basic and Literacy Education: Low
Knowledge	3 RCTs and 6 quasi-experimental studies	Mixed results	Low
Self Efficacy	4 RCTs and 5 quasi-experimental studies	Mixed results depending on intensity of intervention; positive effect across literacy levels for intensive interventions	Low
Behavior	2 RCTs and 1 quasi-experimental study	Improved self-management behaviors, greater improvement in adequate literacy group	Moderate
Adherence	2 RCTs and 2 quasi-experimental studies (1 with post-test only data)	Mixed results related to the intensity of the intervention and measure of adherence	Low
Quality of Life	4 RCTs (1 measured QoL only post-test in intervention group)	Mixed results	Low
Costs	1 RCT	Nonsignificant trend toward reduced cost across literacy groups	Low

BP, blood pressure; ED, emergency department; cRCT, cluster randomized controlled trial; HbA1c, glycosylated hemoglobin; QoL, quality of life; RCT, randomized controlled trial.

Search Results

We identified 42 articles reporting on 40 unique studies to include in our updated review.

Study Quality

Of all 40 studies, we rated two as good quality[125,126] and 30 studies as fair quality.[83,101,124,127-153] One additional study was rated fair for intermediate outcomes and poor for follow-up outcomes.[154] Finally, we rated seven studies of poor quality and excluded them from further review.[155-162]

Characteristics of Included Studies

Below we report on the 33 good or fair quality studies identified in our updated review. Included studies had a wide variety of designs (Table 46). Across all 33 studies, 19 were randomized controlled trials (RCTs), 2 were cluster randomized trials, and 12 were quasi-experimental studies.

With respect to interventions, 14 used one specific strategy to mitigate the effects of low health literacy, and 19 used a mixture of strategies combined into one intervention (Table 47). Of interventions that used one specific low-literacy strategy, two focused on enhancing patient comprehension through alternative document design, one through alternative risk presentation, five through alternative pictorial representations, one through alternative media, and four through a combination of improved readability and alternate document design. Additionally, one intervention focused on the effects of physician notification about patients' literacy status on health outcomes. A total of 19 studies involved mixed interventions; these included a combination of strategies noted above and other strategies to promote improvements in patient knowledge, self-efficacy, behavior, adherence, disease, quality of life, and healthcare services use.

Interventions were tested in study populations with different proportions of individuals with low health literacy. Thirteen studies examined the effect of interventions specifically in low health literacy subgroups, although many were underpowered for these analyses and failed to adequately control for confounding.

Effects of Health Literacy Interventions Using Single Strategies, by Intervention Type

Intervention: Alternative Document Design

Two fair-quality randomized trials addressed the effects of alternative document design on outcomes, including comprehension and choice of higher quality options (Table 48).[127,130] These studies examined the effects of design features including highlighting the common features of comparative information, presenting only essential information, and ordering information so that key information is first.

One study tested simplifying design features in a convenience sample of 303 adults who were asked to examine comparative information about health plans.[127] This study randomized individuals to six groups, which allowed two major comparisons: (1) the effects of presenting information on 13 features of health plans side-by-side, in random order versus with common features first; and (2) the effects of presenting a list of information about the plan (no framework) versus presenting information about four advantages and four disadvantages of the plan (long framework) or presenting information about two advantages and two disadvantages of the plan

(short framework). The investigators found that presenting common features first provided no improvements over side-to-side presentation on information in either low- or high-numeracy participants. However, the short framework and the long framework (for high numeracy participants only) provided small improvement in comprehension (ranging from 0.3 to 0.7 points on a comprehension scale with scores ranging from 0 to 6). The long framework provided significantly worse comprehension than no framework for those with low numeracy (-0.5 points on a comprehension scale with scores ranging from 0 to 6, $P < 0.05$).

In the other study in this category,[130] which was done by the same group of investigators and appears to have used the same participants, the researchers investigated the effects of limiting and focusing information. In this study, both high- and low numeracy participants who received only essential cost and quality information had better comprehension (high numeracy: 0.3 on a scale of 0-3, $P <0.01$; low numeracy 0.7, $P <0.01$) and chose higher quality options (high numeracy: +19 percent, $P <0.01$; low numeracy +23 percent, $P <0.01$) than individuals who received cost, quality, and non-quality information. When all information was presented, ordering of information with cost and quality information (the most important information first) improved comprehension for low-numeracy individuals (+0.6 percent, $P <0.01$) but not for high-numeracy individuals. Ordering had no effect on whether respondents chose higher quality options.

Considering this evidence in aggregate, our research team judged the overall strength of evidence for studies examining alternative document design to be low (Table 43 and Appendix E), indicating that future studies would have a high likelihood of changing estimates of effect. Studies from our previous review did not change overall conclusions. In our previous review, we identified only one study focusing on alternative document design.[163] This RCT compared illustrated narrative text versus bulleted text on genital warts and cervical cancer screening and found no overall differences in comprehension among study arms receiving these presentations. Notably, however, low literacy participants comprehended illustrated materials better than bulleted information.

Intervention: Alternative Numerical Presentation

One fair-quality randomized trial examined the effects of alternative numerical presentation (Table 49).[130] This study was performed in the same population as the studies in the prior section. It examined the effects of presenting information on hospital quality so that the higher number (rather than the lower number) of any indicator indicated a better quality. In this study, listing information so that the higher number was better improved the mean number of correct responses to comprehension questions (+0.4 on a 0-4 scale, $P <0.001$) and the proportion of individuals choosing a higher quality option (+13 percent, $P<0.01$). Results varied by numeracy level, however; participants in the low- but not the high-numeracy subgroup achieved benefit from this approach. This study also investigated whether adding symbols to indicate the concepts of more (+) or less (-) would aid comprehension. We present these results in the next section about pictorial presentations.

In considering the current evidence, our research team felt that the overall strength of evidence was low (Table 43 and Appendix E), indicating that future research would likely change estimates of effect. Our prior review did not change conclusions; although our prior review identified one study of alternative numerical presentation, that study was graded as poor quality.

Intervention: Additive and Alternative Pictorial Representation

Six fair-quality studies[101,128,130,131,137] (including two reported by Peters in the same article) investigated the effects of pictorial representation on outcomes, including comprehension and choice of higher quality options (Table 50). Four were randomized controlled trials and two were quasi-experimental studies. Four investigated the additive effects of pictorial information and two examined alternative pictorial representations.

Of the four trials addressing the additive effects of pictorial information, two focused on the effect of adding symbols to numerical information.[130] One considered in the preceding section examined the effect of adding symbols to hospital quality information presented as either higher-number-better or lower-number-better.[130] The symbols, including designations for more (+), an average number of (), and fewer (-) patients per nurse, had no effect overall. However, adding symbols to the low-number-better condition led to poorer choices (although not poorer comprehension) in high-numeracy participants (percentage choosing higher quality hospital: -19 percent, *P* value not reported). In a similar study from this same group reported in the same article,[130] participants were randomly assigned to one of five conditions to examine two main outcomes: (1) the effect of adding symbols to essential (with or without nonessential) quality information, and (2) the effect of using black and white versus colored traffic-light symbols. Symbols had no overall effect on comprehension but did increase the number of participants choosing high-quality options. Effects varied by whether symbols accompanied only information pertinent to quality or both pertinent and non-pertinent information. Adding symbols to non-pertinent information reduced the choice of high-quality plans among low-numeracy participants, but it made no difference for high-numeracy participants. The effect of using black and white versus colored traffic-light symbols also differed by numeracy level. Low-numeracy participants made better choices with black and white symbols, whereas high-numeracy participants made better choices with colored symbols.

Two other studies examined the effect of adding illustrations to prose.[101,137] One study, a randomized trial of 363 participants (only 4 percent of whom had Rapid Estimate of Adult Literacy in Medicine (REALM) scores <45), found no effect of adding a mind map (a pictorial representation linking key concepts and ideas) to standard arthritis educational materials.[101] The other study, a quasi-experimental study enrolling a convenience sample of 130 adults from academic family medicine clinics, showed no effect of adding illustrations to the auxiliary prescription labels indicating "take with water," "may cause drowsiness," "take with food," "no alcohol," or "take on empty stomach."[137]

The remaining studies examined alternative pictorial representations. In an Internet study randomizing 140 adults (41 percent of whom incorrectly answered the first numeracy question on the Lipkus numeracy scale) to six different conditions, the researchers could determine the effect of grouped versus dispersed dot displays for pictograms for three risk magnitudes (3 percent, 6 percent, 50 percent).[128] They determined that comprehension improved among those receiving grouped dot pictograms. A different quasi-experimental study examined seven teratogen warning symbols in comparison with a standard symbol.[131] The researchers found that participants' understanding that the medication should not be taken if pregnant and that the medication causes birth defects improved if these concepts were represented in separate complementary diagrams (*P* value not reported). They also found that adding text stating "causes birth defects" increased understanding of all symbols.

In aggregate, our research team considered the overall strength of evidence for alternative pictorial representations to be low (Table 43 and Appendix E). Studies made disparate comparisons and found mixed results, precluding clear conclusions. Our prior review found no studies of alternative pictorial representations and, therefore, would not change conclusions.

Intervention: Alternative Media

One fair-quality randomized trial assessed the effects of various types of media on comprehension (Table 51).[142] This study randomized 233 parents or caretakers of children enrolled in Head Start Programs to one of four presentations of informed consent—standard, simplified print, video, computerized—for hypothetical high-risk and low-risk studies. Compared with standard informed consent, the alternative versions had little effect on freely remembered recall of information. However, the computerized version showed a trend toward improving prompted recall (percentage of total information remembered: +4 percent, $P = 0.08$) and the simplified print version showed trends toward improving prompted recall in the low-literacy (as defined by <8th grade reading level on the WRAT) subgroup. Whether such improvements are meaningful is not clear.

Based on findings from the single study above, our research team judged the strength of evidence to be low (Table 43 and Appendix E). However, three studies from our prior review contributed additional information.[164-166] One RCT[164] found that both a simple brochure and video improved comprehension of colon cancer screening information more than usual care, although neither was superior to the other. Two additional nonrandomized trials[165,166] supported these conclusions. One showed that a simple brochure or brochure/video combination on mammography improved mammography rates over a verbal recommendation alone.[167] The other confirmed no differences in comprehension of information on sleep disorders with a simple brochure versus video.[166] In aggregate, these studies suggest that either simplified written information or video information are superior to standard print or verbal recommendations, and that simplified written information and video information provide similar benefits in populations including those with low literacy.

Intervention: Alternative Readability and Document Design

We found three fair-quality randomized trials (4 articles based on 3 studies)[133,141,146,150] and one fair-quality quasi-experimental study[146] examining the effects of interventions that combined simplification of readability and document design (Table 52). One focused on advanced directive,[146,150] one on simplified advice about head trauma,[133] and two on simplified informed consent[141,146] (although one of these provided only post-intervention data, which limited conclusions[146]).

Results of the three studies that provided interpretable data were mixed. Two studies[141,146,150] showed no effect on comprehension by two different combinations of reading and document simplification (see Tables 47 and 52), but both had features limiting interpretation of findings. For instance, participants in one of these studies had a mean REALM score of 65 out of 66;[141] this pattern raises the possibility that the same intervention tested in a population with more low-literacy individuals might have appreciably different results. Another study[146,150] additionally showed changes in unadjusted informed consent completion at 6-month followup, but results were confounded because of cross-over with lack of adjustment for relevant confounders. A third study[133] tested a head trauma advice sheet streamlined by simplifying language, reducing the

number of words, grouping or "chunking" ideas, and using large font sizes and plenty of white space. This study found a 1 point improvement on a comprehension scale with possible scores ranging from 0 to 10, with no interaction by literacy level.

Based on these findings, our research team judged the overall strength of evidence about alternative readability and document design to be low (Table 43 and Appendix E). Studies found mixed results, which are likely attributable, at least in part, to the components of document redesign and methodological bias. Both our prior review and prior sections of the current review aid interpretation of these findings. In our prior review, one study focused on alternative readability alone[168] and showed no association between low readability and improved comprehension. Three other studies focused on a combination of alternative readability and document design and reported mixed results.[169-171]suggested a consistent benefit of lowering the reading level of documents. In prior sections of this review (see alternative document design above), the benefits of document design varied by the components of redesign.

Intervention: Physician Notification of Patient Literacy Status

One fair-quality cluster randomized trial examined the effects of physician notification of patient literacy status on health outcomes including self-efficacy and hemoglobin A1c (HgbA1c), (Table 53).[124] Despite enrolling a population with a high proportion of low-literacy individuals (74 percent with Test of Functional Health Literacy in Adults (TOFHLA) score <16) and increasing physicians' use of more than three communication-enhancing strategies (adjusted odds ratio [OR] 4.7, 95% CI, 1.4 to 16), neither patients' self-efficacy nor HgbA1c changed in any material way with physician notification. Based on this single study, our research team graded the overall strength of evidence as low (Table 43 and Appendix E). There were no studies from our prior review to modify this assessment.

Summary of Interventions Using Single Intervention Design Strategies

In summary, the strength of evidence regarding the effect of specific intervention design features for low health literacy populations is low (Table 43 and Appendix E). This is attributable, in large part, to differences in the interventions (and subsequently results) for studies broadly grouped as follows: alternative document design, alternative numerical presentation, alternative pictorial representation, alternative media, alternative readability and document design, and physician notification of literacy status.

Looking closely within intervention categories, we noted that several specific design features show promise in improving comprehension for low health literacy populations. These features, each of which was tested in only one study, include presenting only essential information, presenting essential information first,[1] presenting quality information with the higher number indicating better quality, and presenting information in pictograms in grouped rather than random format. Additionally, re-examining data from our 2004 review within these categories further suggests potential benefit from using reduced reading level, video, and/or illustrated narratives. In contrast, one study raised questions about whether certain design features, such as colored traffic symbols to denote death rates in hospitals of varying quality or symbols accompanying nonessential quality information, may actually worsen health choices among those with low health literacy.

Effects of Mixed Strategy Interventions, by Analytic Framework

KQ2a. Effect of Mixed Interventions on Use of Health Care Services

We found one good-quality study[125] and five fair-quality studies[136,138,144,145,149] addressing the effects of mixed strategy interventions on use of health care services (Table 54). Four were RCTs;[125,136,144,145] one was a cluster randomized trial;[138] and one used a quasi-experimental design.[149] Two studies providing preventive service education examined rates of preventive services utilization.[138,145] Three others, one promoting adherence[125] and two facilitating self-management,[144,149] examined rates of visits to emergency rooms[125,149] and hospitalizations.[125,144,149] One additional study examined use of recommended services,[136] but the authors did not describe this outcome in sufficient detail to allow interpretation. Compared with the effects of an unspecified handout, one trial providing preventive service education on prostate cancer screening found significant increases in the number of prostate-specific antigen tests ordered after both low readability patient education (adjusted OR, 7.62, 95% CI, 1.62 to 35.83) and cues encouraging patients to talk with their physician (adjusted OR, 5.86, 95% CI, 1.24 to 27. 81). Rates of digital rectal examinations documented by chart review did not change. A cluster randomized trial providing education on colorectal cancer screening, also showed increases in preventive services use (absolute difference in any colorectal cancer test completion over 18-month follow-up: 8.9 percent, $P = 0.003$). The impact differed by health literacy level: absolute difference was 26 percent in the low-health literacy subgroup ($P = 0.002$) and 3 percent in the high-health literacy subgroup ($P = 0.65$).

Compared with usual care, one good-quality RCT promoting medication adherence for congestive heart failure (CHF) reported an 18 percent reduction in emergency room visits (incidence rate ratio: 0.82, 95% CI, 0.70 to 0.95) with intervention.[125] A fair-quality quasi-experimental study promoting asthma self-management through health literacy training and asthma education reported a similar effect, with a striking effect in those who showed improvements in reading (OR 0.34, 95% CI, 0.22 to 0.52).[149] These two studies also reported reductions in hospitalizations with intervention, although the effect did not reach statistical significance in the better quality study (incidence rate ratio: 0.81, 95% CI, 0.64 to 1.04). A third study, a fair-quality trial also focused on CHF self-management,[144] reported no overall reduction in hospitalizations but significant reductions in a subgroup of individuals of low health literacy (incidence rate ratio: 0.39, 95% CI, 0.16 to 0.91).

Based on these findings, our research team graded the strength of evidence for the effect of mixed interventions on emergency room visits and hospitalizations as moderate (Table 45 and Appendix E). Our prior review found no studies examining this outcome; it, therefore, did not modify our conclusions.

KQ2b: Effect of Mixed Interventions on Health Outcomes

Knowledge. We identified nine fair-quality studies addressing the effects of mixed strategy interventions on knowledge (Table 55).[83,136,139,143,144,147,148,153,154] Three were RCTs[136,143,144] and the remaining six were quasi experimental studies.[83,139,147,148,153,154] Two focused on promoting adherence,[143,154] five on promoting self-management of chronic illness,[83,136,139,143,144,153] one onpromoting informed consent,[148] and one on promoting weight loss.[147] Only one examined

knowledge as its primary outcome.[148] Additionally, only one examined literacy as a moderator of intervention effect.[139]

In aggregate, studies found mixed results; findings did not seem to be related to study design, intervention or disease focus, the health literacy level of included participants, or the health literacy strategies employed as part of the intervention. One randomized trial of a self-management intervention,[144] one quasi-experimental study promoting adherence,[154] one quasi-experimental study of written and oral consent,[148] and one quasi-experimental study promoting weight loss[147] reported improvements in knowledge with the intervention. However, which components of these interventions were the effective components remained unclear. One additional quasi-experimental study showed positive effects for the high-health literacy, but not low-health literacy, group at 3 month followup.[139]

Given the mixed findings, our research team judged overall strength of evidence to be low (Table 44 and Appendix E). However, fourteen studies from our prior review (including twelve that examined knowledge as their primary outcome) contributed additional information. Six have been considered above because they addressed specific alternative presentations of health information. Six additional studies addressed mixed interventions and are considered here.[165,172-176] Five of these six studies, including two RCTs,[175,176] found improvements in knowledge with interventions as diverse as an interactive videodisc program about self-care of fatigue in cancer patients, low literacy nutrition classes, illustrated simplified brochures on polio immunization, a cholesterol education video, and a CD-ROM on prostate cancer screening. The remaining nonrandomized trial found no improvement in knowledge with the addition of a color medication schedule to verbal teaching. With continued mixed results (10 of 15 studies overall with knowledge improvements), the research team concluded that the overall strength of evidence was still low (Table 44 and Appendix E), with effect estimates that are likely to change substantially with new results.

Self Efficacy. We identified nine fair quality studies addressing the effects of mixed strategy interventions on self-efficacy (Table 56). Four were RCTs[129,136,144,151,152] and five were quasi-experimental studies.[132,147,149,153,154] Two focused on promoting adherence,[132,154] five on promoting self-management,[129,136,144,149,152,153] one on arthritis treatment,[151] and one on weight loss.[147] None examined self-efficacy as its primary outcome; only one examined literacy as a moderator of effect.[136] One reported self-efficacy results only post-intervention, which limited conclusions.[154]

In aggregate, studies found mixed results, which may be related to the intensity of the intervention. Two RCTs[129,144,152] and one quasi-experimental study[149] with intensive self-management interventions including frequent and prolonged participant contact showed improvements in self-efficacy. Additionally, one study that targeted both patients and providers (although with less intensive and less prolonged contact for each than other effective interventions) showed increases in self-efficacy.[147] Other studies, including two randomized trials, showed negative results[132,136,151,153] and no differential effect by health literacy level.[136] Based on these mixed findings, our research team judged the overall strength of evidence to be low (Table 44 and Appendix E). No studies from our prior review addressed this outcome.

Behavioral intent. We found no studies addressing the effects of mixed health literacy interventions on patients' intent to perform specific health behaviors. Similarly, our prior review found no studies addressing this outcome.

Skill. We found no studies addressing the effects of mixed health literacy interventions on patients' skills. However, two studies from our prior review[177,178] addressed label reading skills and found mixed results.

Behavior. Three fair-quality studies addressed the effect of mixed strategy interventions on actual behaviors (Table 57).[129,139,144,152] Two were RCTs; one was a quasi-experimental study. All involved individual or group counseling that taught self-management behaviors and measured aggregate self-management behaviors. Additionally, two studies measured individual self-management behaviors for diabetes (including diet, physical activity, foot care, medication adherence, and glucose self-monitoring).[129,139,152] Only one analyzed these effects by health literacy level.[139]

In aggregate, these studies suggested that self-management interventions including individual and group counseling improved aggregate self-management behaviors. However, in the only study to examine effects by health literacy status,[139] improvements were statistically significantly greater for those who had adequate health literacy than for those with inadequate health literacy in adjusted analyses. Based on these studies, our research team judged the strength of evidence regarding the effects of self-management interventions on behavior as moderate (Table 44 and Appendix E).

Three studies in our prior review also addressed behavior, although their intervention focus was different.[175,177,179] All three had special diet interventions and measured dietary change and/or caloric intake. These studies found mixed results, precluding definitive conclusions about the effects of low-health literacy diet interventions on behavior.

Medication adherence. We found one good quality[125] and three fair-quality studies[83,139,143] addressing the effect of mixed literacy interventions on adherence to medication regimens (Table 58). Two were RCTs[125,143] and two were quasi-experimental studies.[83,139] Three included interventions that were designed specifically to promote adherence.[125,139,143] The fourth[83] was a self-management intervention that measured medication adherence only post-intervention in a subset of patients, which limited drawing any conclusions.

In the three studies contributing interpretable data,[125,139,143] effects were mixed, which appeared to be related to both the intensity of the intervention and the measure of adherence. The good-quality RCT,[125] which involved an intensive intervention focused at both patients and their providers, found improved adherence (+10.9 percent, 95% CI, 5 percent to 16.7 percent) during the intervention period using Medication Event Monitoring Systems (MEMS) to assess adherence. The effect, however, attenuated at 3 months after completion of the intervention (+3.9 percent, 95% CI, -2.8 percent to 10.7 percent). Two other studies[139,143] which used less intensive interventions and measured adherence by self-report, found no effect, although one showed a trend toward improved adherence among a subgroup of individuals who were initially non-adherent (+12 percent, $P = 0.08$, when counting as adherent those who disagreed that they missed medications for any of the four reasons on the Morisky questionnaire).[143]

Based on the findings above, our research team judged the strength of evidence for the effects of mixed interventions on adherence to be low (Table 44 and Appendix E). Only one study from our previous review measured adherence and found no effect of a color medication schedule.[172] This nonrandomized trial did not change our conclusion about the overall strength of evidence for this outcome.

Disease Prevalence and Severity. We found one good-quality[126] and six fair-quality studies[83,129,135,136,139,140,152] addressing the effects of mixed strategy interventions on disease prevalence and severity (Table 59). Four were RCTs[126,129,135,136,152] and three were quasi-experimental studies.[83,139,140] Five measured biomarkers of disease;[126,129,136,139,140,152] and two measured symptoms.[83,135] In general, these studies reported mixed results; this may be attributable, at least in part, to intervention and study design.

Three studies addressed the effects of diabetes self-management interventions on disease biomarkers (including HgbA1c, blood pressure, and body mass index [BMI]).[129,136,139,152] Two fair quality RCTs, found no effect on HgbA1C, blood pressure, or BMI.[129,136,152] By contrast, a fair quality quasi-experimental study of a less intensive intervention found a statistically significant decrease in HgbA1C;[139] without a control group, however, we cannot judge the importance of this finding.

Two other studies addressed the effects of diabetes disease management programs (i.e., self-management plus pharmacist adjustment of medication) on disease biomarkers.[126,140] These studies appeared to test the same intervention in a quasi-experimental[140] and a randomized design.[126] The RCT showed a significant decrease in HgbA1c in the low-health literacy group (adjusted absolute difference: -1.4 percent, 95% CI, -2.3 percent to -0.6 percent) but not in the high-health literacy group (adjusted absolute difference: -0.5 percent, 95% CI, -1.4 percent to 0.3 percent). Systolic blood pressure was also significantly lowered among all participants (adjusted absolute difference: -7.6 mmHg, 95% CI, -13 to -2.2 mmHg). Exactly which component of this intervention was efficacious remains unclear, however. Although the lack of efficacy of other self-management interventions argues that the pharmacist adjustment of medication may be the critical factor, the self management component in this study employed a wider variety of strategies to mitigate low health literacy (e.g., simple language, simple organizational structure, pictures, teach back, repetition) than other studies.

Two studies addressed the effects of mixed strategy interventions on symptom control,[83,135] although only one had adequate power to test its effects on disease severity.[135] This fair-quality randomized trial, which tested the effects of Adult Basic and Literacy Education as an adjunct to depression management, showed statistically significant reductions in scores on the PHQ9 (the nine-item depression scale of the Patient Health Questionnaire) over multiple follow-ups.

Based on the findings above, our research team judged the strength of evidence separately for self-management, disease-management, and adult basic and literacy interventions. We concluded that the strength of evidence is low for self-management interventions, moderate for disease management interventions, and low for Adult Basic and Literacy Education interventions (Table 44 and Appendix E). No studies from our prior review included these types of interventions. However, two RCTs from our prior review[179,180] found no effect of special nutrition education programs on cholesterol (2 studies) or blood pressure (1 study).

Quality of Life. One good quality[125] and three fair quality[129,144,151,152] RCTs addressed the effects of mixed strategy interventions on quality of life (Table 60); however, none used quality of life as the primary outcome. Two focused on general quality of life[129,151,152] and two focused on disease-specific quality of life.[125,144] One measured quality of life only after the intervention in the intervention group,[125] thereby limiting conclusions.

The three studies providing interpretable data yielded mixed results. Two studies reported no effects of self-management interventions on well-validated quality of life measures, including the mental and physical health subscales of the Medical Outcomes Study Short Form 12 (SF-12)[129,152] and the Minnesota Living with Heart Failure scale (MLHF).[144] One of the studies,

however, reported reductions in the number of bed days in the past month (adjusted absolute difference: -1.7 days/month, 95% CI, -3.3 to -0.1 days/month) for people assigned to an intensive telephone counseling intervention with 39 patient contacts.[129,152] A third trial on arthritis management intervention reported mixed effects, with no effects on the Health Assessment Questionnaire (HAQ),[151] but improvements on the mental health subscale of the SF-36.

Based on findings described above, our research team judged the strength of evidence for the effects of mixed interventions on quality of life to be low (Table 44 and Appendix E). Our prior review found no studies examining this outcome; it, therefore, did not modify our conclusions.

KQ1c. Effect of Mixed Interventions on Health Care Costs

One good-quality RCT examined the cost-effectiveness of its intervention to promote adherence to CHF medication[125] (Table 61). This intensive pharmacist-led intervention, which included patient education and skill building, graphic medication labels, monitoring of adherence, and notification of providers, showed trends toward cost savings (-$2960, 95% CI, -$7603 to $1338) compared with usual care when considering intervention, outpatient, and inpatient costs. Based on this study, our research team graded the strength of evidence for the effects of mixed interventions on healthcare costs as low (Table 44 and Appendix E). Our prior review found no studies addressing this outcome and did not modify our conclusions.

KQ1d. Effect of Mixed Interventions on Disparities

We found no studies addressing the effects of mixed health literacy interventions on patients' intent to perform specific health behaviors. Similarly, our prior review found no studies addressing this outcome.

Summary of Interventions Using Mixed Intervention Strategies

The strength of evidence for studies combining multiple strategies to mitigate the effects of low health literacy on outcomes was more variable than for single-feature interventions. We found moderate strength of evidence that studied interventions change health care service use. Specifically, intensive self-management and adherence interventions appear to be effective in reducing emergency room visits and hospitalizations. Additionally, educational interventions and/or cues for screening increased colorectal cancer and prostate cancer screening. We note, however, that the health benefits of additional prostate cancer screening are questionable and that increased screening rates could be a marker for poor decisionmaking.

Evidence of moderate strength indicates that some interventions change health outcomes. For instance, intensive disease-management programs appear to be effective at reducing disease prevalence and severity. Furthermore, self-management interventions increased self-management behavior; in studies that performed subgroup analyses, however, the effect was greater in high health literacy populations than in lower health literacy populations. The effects of other interventions on other health outcomes, including knowledge, self-efficacy, and quality of life, were mixed; thus, the strength of evidence was low.

Too few studies addressed the effects of health literacy interventions on the outcomes of behavioral intent, health-related skills, cost, and disparities to draw any meaningful conclusions; the strength of evidence is low.

Cross-cutting Observations About Interventions Designed to Mitigate Low Health Literacy

Our findings provide insight into the specific features of interventions designed to mitigate low health literacy and help illuminate what factors may be key in making the interventions effective. Common features across nearly all of the interventions that improved distal outcomes (e.g. self-management, hospitalizations, mortality) was their high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional (e.g., pharmacist, diabetes educator; see).[125,126,144,149] Additionally, six studies in our update examined the impact of interventions on three or more outcomes[83,125,129,136,139,144] (see Table 47); they preliminarily suggest that effective interventions to mitigate the effects of low health literacy may work by increasing knowledge,[139,144] increasing self-efficacy,[129] or changing behavior.[125,129,139,144]

Table 46. Summary of included intervention studies

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Basic Interventions: Alternate Document Design							
Greene et al., 2008[127]	RCT (303)	Fair	50% Low (score less than 10 on DR Numeracy Test)	(1) Side-by-side comparison of characteristics (2) No framework	(1)Common/unique presentation of characteristics (2a) Short framework (2b) Long framework	Comprehension	Yes
Peters et al., 2007[130] (Study 1)	RCT (303)	Fair	50% Low (score less than 10 on DR Numeracy Test)	Non-ordered, non-quality info.	1) Ordered cost, quality, non-quality info. 2) Cost and quality info. only	Comprehension, Choice of higher quality option	Yes
Basic Interventions: Alternate Numerical Presentation							
Peters et al., 2007[130] (Study 3)	RCT (303)	Fair	50% Low (score less than 10 on DR Numeracy Test)	Lower is better, no symbols	1) higher is better, no symbols 2) lower is better, symbols 3) higher is better, symbols	Comprehension, Choice of higher quality option	Yes
Basic Interventions: Alternate Pictorial Representations							

[a]Read from Table; [b]determined through personal communication with author
CHD, coronary heart disease; CHF, congestive heart failure; cRCT, cluster randomized controlled trial; HgbA1c, glycosylated hemoglobin; inadeq., inadequate; info., information; MDs, medical doctors; NA, not applicable; NOS, not otherwise specified; NR, not reported; PDA, personal digital assistant; pts, patients; Quasi-, quasi-experimental study;RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy for Adults; sTOFHLA, short form Test of Functional Health literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults.

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Hwang et al., 2005[137]	Quasi-, post-post (130)	Fair	5% REALM ≤ 6th grade 22% REALM 7-8th grade	Medication label text: A. Take with water B. May cause drowsiness C. Take with food D. No alcohol E. Take on an empty stomach	Medication label text + illustration	Comprehension	No
Mayhorn and Goldsworthy, 2007[131]	Quasi-, post-only (700)	Fair	42.9% Low literacy (REALM, NOS)	Original teratogen symbol (slash through pregnant woman)	1) Original symbol, but woman taking pill 2) Cross and skull bones in pregnant belly 4) 2 pictures: Original symbol + skull bones in pregnant belly 5) 2 pictures: #4 but more caricatured 6) 1 picture combining original symbol + skull bones in pregnant belly 7) skull bones in pregnant belly + inlay with slash through person taking pills	Comprehension	No

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Peters et al., 2007[130] (Study 2)	RCT (303)	Fair	50% Low (score less than 10 on DR Numeracy Test)	Numbers only	1) death rates accompanied by black/white symbols 2) death rates accompanied by traffic symbols 3) death rates and satisfaction accompanied by black/white symbols 4) death rates and satisfaction accompanied by traffic symbols	Comprehension, Choice of higher quality option	Yes
Walker et al., 2007[101]	RCT (363)	Fair	15% with REALM < 60 (9th grade)	Standard Arthritis Booklet	Standard Arthritis booklet + Mind Map	Knowledge	No
Wright et al., 2009[128]	RCT (140)	Fair	41% Low (incorrect answer to 1st question on Lipkus numeracy scale)	Dispersed dot display (3 different risk magnitudes: 3%, 6%, 50%)	Grouped dot display (3 different risk magnitudes: 3%, 6%, 50%)	Comprehension	Yes
Basic Interventions: Alternate Media							
Campbell et al., 2004[142]	RCT (233)	Fair	50% Low (≤ 8th grade reading level on Woodcock Johnson) Average REALM score 56.3	Standard print consent form	(1) Simplified print consent form (2) Video consent (3) Computerized consent	Knowledge	Yes

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Basic Interventions: Alternate Readability and Document Design							
Coyne et al., 2003[141]	RCT (226)	Fair	Mean REALM: 65	Standard Consent Form	Simplified consent form	Comprehension	No
Sudore et al., 2006[134]	Quasi-, post-only (204)	Fair	22% TOFHLA Inadeq. 18% TOFHLA Marginal	None	Simplified consent form	Comprehension	Yes
Sudore et al., 2007[146] Sudore et al., 2008[150]	RCT (205)	Fair	40% TOFHLA < 22 (Inadeq. or Marginal	Standard Advanced Directive	Simplified Advanced Directive	Comprehension	No
Yates and Pena, 2006[133]	RCT (200)	Fair	1.5% REALM < 7th grade[a] 14% REALM 7-8th grade[a]	Standard head trauma advice form	Simplified head trauma advice form	Comprehension	No
Physician Notification of Patient Literacy Status							
Seligman et al., 2005[124]	cRCT (63 MDs, 182 pts)	Fair	74% TOFHLA Inadeq. 16% TOFHLA Marginal	Usual Care for Diabetes	Physician notification of patients' health literacy status	Self efficacy HgbA1c Physician use of effective communication Strategies	No
Mixed Interventions: Focused on Adherence							
Bosworth et al., 2005[143]	RCT (588)	Fair	38% low literacy[b]	Usual care	Tailored Adherence Intervention	Knowledge, Adherence	No

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Brock and Smith, 2007[154]	Quasi-, pre-post (51)	Fair (although poor for adherence)	55% REALM < 8th grade	NA	Adherence Video on PDA	Knowledge, Adherence	No
Kripalani et al., 2007[132]	Quasi-, pre-post (242)	Fair	42% REALM ≤ 6th grade 37% REALM 7-8th grade	None	CHD adherence intervention (pill card)	Self-efficacy	No
Murray et al., 2007[125]	RCT (314)	Good	29% "not literate" on sTOFHLA (NOS)	Usual Care	CHF Adherence Intervention	Adherence, Quality of Life, Use of Health care Services, Cost	No
Mixed Interventions: Focused on Self-Management							
DeWalt et al., 2006[144]	RCT (127)	Fair	41% sTOFHLA inadeq.	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	Knowledge, Self-efficacy, Behavior, Quality of Life, Use of Healthcare Services	No
Wallace et al., 2009[153]	Quasi-, pre-post (250)	Fair	29% TOFHLA inadeq. 14% TOFHLA marginal	NA	Diabetes Self-Management Intervention	Knowledge, Self-efficacy,	No
Gerber et al., 2005[136]	RCT (144)	Fair	56% sTOFHLA < 22 (Inadeq. or marginal)	Usual Care + computerized quizzes on diabetes-related concepts	Diabetes Self-Management Intervention	Knowledge, Self-efficacy, HgbA1c, Use of Healthcare Services	Yes
Kim et al., 2004[139]	Quasi-, pre-post (92)	Fair	23% sTOFHLA < 22 (Inadeq. or marginal) (15% inadeq. on TOFHLA)	None	Diabetes Self-Management Intervention	Knowledge, Behavior, HgbA1c	Yes

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Paasche-Orlow et al., 2005[83]	Quasi-, pre-post (73)	Fair	22% sTOFHLA Inadeq.	NA	Asthma Self-Management Intervention	Knowledge, Adherence, Asthma symptom control	No
Robinson et al., 2008[149]	Quasi-, pre-post (110)	Fair	Mean Gilmore Oral Reading Test Score: 3.2	NA	Asthma Self-Management Intervention	Self-efficacy, Use of Healthcare Services	No
Schillinger et al., 2008[129] Schillinger et al., 2009[152]	RCT (339)	Fair	59% sTOFHLA ≤ 22 (inadeq. or marginal)	usual care	1) Diabetes Self Management Program (automated telephone delivery) 2) Diabetes Self-Management Program (group medical visit delivery)	Self-efficacy, Behavior, Hgba1c (and other biomarkers), Quality of Life	No
Mixed Interventions: Focused on Disease Management							
Rothman et al., 2004[140]	Quasi-, pre-post (159)	Fair	55% Lower Literacy 32% REALM ≤ 3rd grade 23% REALM Score 4-6th grade	NA	Diabetes Self-Management Intervention	HgbA1c (and other biomarkers)	Yes
Rothman et al., 2004[126]	RCT (217)	Good	38% REALM ≤ 6th grade	1-hour education session	Diabetes Self Management Intervention	HgbA1c (and other biomarkers)	Yes
Mixed Interventions: Focused on Screening							

Table 46. Summary of included intervention studies (continued)

Source	Design (sample size)	Quality Score	Population, Health Literacy Levels	Control	Intervention	Outcomes	Analysis Stratified by Literacy
Kripalani et al., 2007[145]	RCT (303)	Fair	38% REALM < 3rd grade 18% REALM 4-6th grade 23% REALM 7- 8th grade	Handout, NOS Unclear if prostate content or other content	1) Educational Intervention on Prostate Cancer Screening 2) Cue to Discuss Prostate Cancer screening	Use of Healthcare Services	No
Ferreira et al., 2005[138]	cRCT (113 MDs, 1978 pts)	Fair	31% Low (< 9th grade on TOFHLA) Note: measured only in 19% of patients	Usual Care	Educational Intervention for Physicians and Patients on Colorectal Cancer screening	Use of Healthcare Services	Yes
Mixed Interventions: Focused, Other							
Davis et al., 2008[147]	Quasi-, pre-post (101)	Fair	49% REALM < 6th grade 22% REALM 7-8th grade	None	Weight loss intervention	Knowledge, Self-efficacy	No
Kripalani et al., 2008[148]	Quasi-, post only (408)	Fair	21% REALM ≤ 3rd grade 25% REALM 4-6th grade 31% REALM 7-8th grade	No control	1) Modified Print informed Consent with Oral Overview	Knowledge	Yes
Rudd et al., 2009[151]	RCT (127)	Fair	19% REALM ≤ high school	Arthritis Management Intervention (arthritis pamphlet, medicine calendar, hospital map)	Arthritis Management Intervention + Individual Counseling	Self-efficacy, Quality of Life	No
Weiss et al., 2006[135]	RCT (70)	Fair	Mean REALM score 47	Usual care	Adult Basic and Literacy Education (ABLE)	Depression Severity	No

Table 47. Intervention detail

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Basic Interventions: Alternative Document Design									
Greene et al., 2008[127]	1) Common presentation of information (vs. random presentation) 2) Short Framework (vs. long or no framework)	Print	1	NR	Researchers	Chunking of ideas	NA	NA	Yes[a]
Peters et al., 2007[130] (study 1)	1) Ordered info. (vs. unordered info.) 2) Essential info. (vs. nonessential info.)	Print	1	< 1 hour[a]	Researchers	Ordering, Essential info. only	NA	NA	Yes[a]
Basic Interventions: Alternative Numerical Presentation									
Peters et al., 2007[130] (study 3)	1) Higher number better (vs. lower number better)	Print	1	< 1 hour[a]	Researchers	Numerical Simplification	NA	NA	Yes[a]

[a] determined via personal contact with authors

avg, average; CHD, coronary heart disease; CHF, congestive heart failure; DM, diabetes; HIV, human immunodeficiency virus; hr, hour; HTN, hypertension; info., information; med, medicine; min, minute; NA, not applicable; NA, not applicable; NOS, not otherwise specified; NR, not reported; PCP, primary care provider; PDA, personal digital assistant; Q and A, question and answer; vs., versus.

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Basic Interventions: Alternative Document Design									
Basic Interventions: Additive and Alternative Pictorial Representation									
Wright et al., 2009[128]	Grouped dots in pictogram (vs. dispersed dots)	Print	1	NR	Researchers	Graphical simplification	NA	NA	NR
Hwang et al., 2005[137]	Illustrations (vs. none)	Print	1	NR	Researchers	Graphics	NA	NA	No
Mayhorn and Goldsworthy, 2007[131]	7 alternate teratogen symbols	Print	1	25 min	Researchers	Graphics	NA	NA	Yes
Walker et al., 2007[101]	Mind map (vs. none)	Print	1	Unknown[a]	Researchers[a]	Conceptual Depiction	NA	NA	No
Peters et al., 2007[130] (study 2)	1) color symbols (vs. black-white or no symbols)	Print	1	< 1 hour[a]	Researchers	Graphics, Color	NA	NA	Yes[a]
Peters et al., 2007[130] (study 3)	1) symbols to indicate higher/lower quality (vs. none)	Print	1	< 1 hour[a]	Researchers	Graphics	NA	NA	Yes[a]
Basic Interventions: Alternative Media									

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Campbell et al., 2004[142]	1) Simplified consent form 2) Video consent 3) Computerized consent	Print, Video, Computer	1	< 1 hr	Researchers	Simple language, Chunking of ideas, White space, Pictures, Oral delivery	NA	NA	Yes[a]
Basic Interventions: Alternative Reading Level and Document Design									
Coyne et al., 2003[141]	Simplified consent form (vs. standard form)	Print	1	NR	Researchers	7th-8th grade reading level, Simple language, 1 idea/paragraph, Large font, White space, Pictures	NA	NA	No
Sudore et al., 2007[146] Sudore, 2008[150]	Simplified advanced directive (vs. standard)	Print	1	< 30 min	Researchers	5th grade reading level, values clarification questions. Large Font, Graphics	NA	NA	No
Sudore et al., 2006[134]	Simplified consent form	Print, Oral	1	10 min	Researchers	6th grade reading level. Simple language, Large Font, Teach back	NA	NA	No

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Yates and Pena, 2006[133]	Simplified instruction sheet (vs. standard form at same readability)	Print	1	5-10 min	Researchers	Word reduction, Simple language, Chunking of ideas, Large Font, White space	NA	NA	Yes[a]
Basic Interventions: Provider Notification of Patient Literacy Status									
Seligman et al., 2005[124]	Provider notification of patient literacy level	Print	1	NA	Researchers	NA	NA	NA	No
Mixed Interventions: Adherence									
Bosworth et al., 2005[143]	Adherence intervention for HTN (education, skill building)	Telephone	~12	44 min (avg)	Nurses	Oral presentation, key concepts, information given to family/friend[a]	Yes	Yes	No
Brock and Smith, 2007[154]	Adherence intervention for HIV (education, skill building)	Video on PDA	1	17 min	Self	Simple language, Pictures/Graphics	No	NR	Yes
Kripalani et al., 2007[132]	Adherence intervention for CHD (pill card)	Individual Counseling, Print	1[a]	5 min[a]	Pharmacist	Pictures, Large Font	Yes	Social Cognitive Theory[a]	Yes
Murray et al., 2007[125]	Adherence intervention for CHF (education, graphic med labels, skill building, monitoring and feedback, provider communication)	Patient: Individual counseling, Print Provider: telephone, paging, email	Variable, range not available[a]	~10-20 hours[a]	Pharmacist	6th grade reading level, Organization by mental schema, Lists/short paragraphs, Pictures	Yes	No (but patient centered principles)	Yes

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Mixed Interventions: Self-Management									
DeWalt et al., 2006[144]	Self Management intervention for CHF (education, skill building)	Individual counseling, Print, Telephone	10 to 16	Not measured[a]	Pharmacist or Health Educator	6th grade readability, Teach back	Yes	Social Cognitive Theory[a]	Yes
DeWalt et al., 2009[181] Wallace et al., 2009[153]	Self Management Intervention for DM (education, goal setting)	Individual counseling, Print, Telephone	3	20-45 minutes based on measurement at 1 site	Researcher	Simple language, Conversational tone, Pictures	No	Yes	Yes
Gerber et al., 2005[136]	Self Management Intervention for DM (education, feedback)	Computer with audio/video	2.9 on average[a]	53.5 min on average[a]	Self	Audio/Video, Testimonials	Yes	Yes	No
Kim et al., 2004[139]	Self Management Intervention for DM (NR)	Individual and group counseling	4	10 hours[a]	Diabetes Educators	6th grade reading level[a]	No[a]	None[a]	NA[a]
Paasche-Orlow et al., 2005[83]	Self Management Intervention for Asthma (skill building)	Individual counseling, Print	1	30 min+	Researcher	Teach back	No	N	No
Robinson et al., 2008[149]	Self Management Intervention for Asthma (literacy education, asthma education, skill building, goal setting, communication training)	Group counseling	29	68 hrs	Trained facilitators, NOS	NR	No	NR	Yes for asthma, No for literacy

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Schillinger et al., 2008[129] Schillinger et al., 2009[152]	2 Self Management Interventions for DM (education, skill building)	1) Telephone 2) Group Counseling	1) 39 2) 9	1) 312 min 2) 810 min	1) Automated Calls, Nurse 2) PCP, health educator	Oral presentation[a]	Yes[a]	No[a]	Yes[a]
Mixed Interventions: Disease Management									
Rothman et al., 2004[140]	Disease Management Intervention for DM (education, trouble-shooting, med adjustment)	Individual counseling, Print, Telephone	~15[a]	~336 min[a]	Pharmacists	Simple language, Pictures, Simple organizational structure, Teach Back	Yes	No (general principles of Social Cognitive Theory applied) [a]	No[a]
Rothman et al., 2004[126]	Disease Management Intervention for DM (education, skill building, med adjustment)	Individual counseling, Print, Telephone	13+	463.2 min[a]	Pharmacists or Diabetes Care Coordinators	Simple language, Pictures, Simplified organizational structure, Teach Back, Repetition	Yes	No (general principles of Social Cognitive Theory applied) [a]	Yes[a]
Mixed Interventions: Screening									
Kripalani et al., 2007[145]	1) Educational Intervention on Prostate Cancer Screening 2) Cue to Discuss Prostate Cancer Screening	Print	1[a]	Not measured[a]	Researchers	Simple language, Pictures, Large Font, Key Concepts, Q and A	No	None[a]	Yes

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Ferreira et al., 2005[138]	Educational Intervention on Colorectal Screening	Provider: workshops Patient: Video, Print	Provider: 4-5 Patient: NR	Provider: 5-6 hr Patient: NR	Researchers	Provider: education on low health literacy and communication strategies, NOS[a] Patient: Simple language[a]	Providers: Yes Patients: No	Provider: none (although followed quality improvement principals) [a] Patient: Health Belief Model[a]	Providers: NR Patients: Yes
Mixed Interventions: Other									
Davis et al., 2008[147]	Weight loss Intervention	Provider: workshops (education) Patients: Video (education, motivation)	Provider: 2 Patient: 1	Provider: 4 hr Patient: 15 min	Researchers	Physician: specific education interactions with low lit population Patient: 1st-2nd grade readability, teach back	No	Yes	No
Kripalani et al., 2008[148]	1) Modified Print Informed Consent with Oral Overview	1) Print 2) Individual oral education	1	7-8 min on average[a]	Researchers	1) 8th grade readability, Chunking of ideas 2) teach back	No	No	No
Rudd et al., 2009[151]	1) Arthritis Management Intervention (education, medicine calendar, hospital map) 2) Arthritis Management Intervention + Individual Counseling	Individual Counseling, Print	1+[a]	~1 hr[a]	Arthritis Educator	5th to 8th grade readability, Avoidance of jargon	Yes (intervention 2)	Social Cognitive Theory[a]	Yes[a]

Table 47. Intervention detail (continued)

Author	Description	Medium	# of sessions	Contact time	Who Delivered	Literacy Strategies	Individual Tailoring	Theory Driven	Pre-testing
Weiss et al., 2006[135]	Adult Basic and Literacy Education Intervention (education and job skill building)	Individual Counseling, Print, Computer	NR	18.1 hr (range 0-74 hr)	Program Staff	4th grade readability, Short Sentences, Large Font, White Space, Avoid jargon	No	None (although focus on empowerment and locus of control)[a]	Yes[a]

Table 48. Single intervention strategies: Alternative document design

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy/ Numeracy	Outcomes	Difference
Greene et al., 2008[127] Fair	RCT	(1) Side-by-side comparison of characteristics (2) No framework	(1) Common/unique presentation of characteristics (2a) Short framework (2b) Long framework	303	50% Low (score less than 10 on DR Numeracy Test)	Mean # of correct responses to comprehension questions (range 0-6)	**Common vs. Side to Side** (unadjusted) High Numeracy Subgroup: Comprehension: -0.3, NS Low Numeracy Subgroup: Comprehension: -0.3, NS **Short framework vs. No** (unadjusted) High Numeracy Subgroup: Comprehension: +0.7, ($P < 0.05$) Low Numeracy Subgroup: Comprehension: +0.3, ($P < 0.05$) **Long framework vs. No** (unadjusted) High Numeracy Subgroup: Comprehension: +0.5, ($P < 0.05$) Low Numeracy Subgroup: Comprehension: -0.5, ($P < 0.05$)

NS, not significant; info, information; NR, not reported; pert, pertinent information; RCT, randomized controlled trial; vs., versus.

Table 48. Single intervention strategies: Alternative document design (continued)

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy/ Numeracy	Outcomes	Difference
Peters et al., 2007[130] (Study 1) Fair	RCT	Non-ordered, non-quality info	1) Ordered cost, quality, non-quality info (= all) 2) Cost and quality info only (= pert only)	303	50% Low (score less than 10 on DR numeracy test)	Mean # correct responses to comprehension questions (range 0-3) % choosing higher quality hospital	**Ordered, all vs. Control:** High Literacy Subgroup: Comprehension: +0.1, NS Choice: +5%, NS Low Literacy Subgroup: Comprehension: +0.6, (P < 0.01) Plan Choice: +9%, NS P for literacy interaction: comprehension: (P < 0.05) Choice: NS **Ordered, pert only, vs. control:** Overall: Comprehension: +0.4, (P < 0.01) Choice: +21%, (P < 0.01) High Numeracy Subgroup: Comprehension: +0.3, (P < 0.01) Choice: +19%, NR Low Numeracy Subgroup: Comprehension: +0.7, (P < 0.01) Choice: +23%, NR P for interaction: comprehension: (P < 0.05) Choice: NS

Table 49. Single intervention strategies: Alternative numerical presentation

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% population with Limited Literacy/ Numeracy	Outcomes	Difference
Peters et al., 2007[130] (Study 3) Fair	RCT	Lower is better, no symbols	1) higher is better, no symbols 2) lower is better, symbols 3) higher is better, symbols	303	50% (score < 10 on DR Numeracy Test)	Mean # correct responses to comprehension questions (range 0-4) % choosing higher quality hospital	**Higher is better vs. Lower is better:** Comprehension: Overall: +0.4, ($P < 0.001$) High literacy Subgroup:+0.2, NS Low literacy Subgroup: +0.7, ($P < 0.01$[a]) Choice: Overall: +13%, ($P < 0.01$) High Literacy Subgroup: NR (interaction by symbols) Low Numeracy Subgroup: +20%, ($P < 0.05$[a]) **Symbols vs. No Symbols:** Comprehension: Overall: NR, $P < 0.10$ High Literacy Subgroup: -0.3*, ($P < 0.05$) Low Literacy Subgroup: -0.1, NR[a] Choice: Higher Literacy Subgroup: -7, NR[a] Lower Literacy Subgroup: +0.5, NR[a] **Higher # better, no symbols vs. Control:** High Literacy Subgroup: Comprehension: +0.3, NR Choice: -4%

[a]Calculated by reviewers
NS, not significant; NR, not reported; RCT, randomized controlled trial; vs., versus.

Table 49. Single intervention strategies: Alternative numerical presentation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% population with Limited Literacy/ Numeracy	Outcomes	Difference
							Low Literacy Subgroup: Comprehension: +0.3, NR Choice: +26%, ($P < 0.05$) **Lower # better + symbols vs. Control:** High Literacy Subgroup: Comprehension: -0.2, NR Choice: -19% Low Literacy Subgroup: Comprehension: -0.2, NR Choice: +12%, NR **Higher # better + symbols vs. Control:** High Literacy Subgroup: Comprehension: -0.1, NR Choice: +1% Low Literacy Subgroup: Comprehension: +0.5, NR Choice: +25%, ($P < 0.05$)

Table 50. Single intervention strategies: Additive and alternative pictorial representation

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Peters et al., 2007[130] (Study 2) Fair	RCT	Numbers only	1) death rates accompanied by black/white symbols 2) death rates accompanied by traffic symbols 3) death rates and satisfaction accompanied by black/white symbols 4) death rates and satisfaction accompanied by traffic symbols	303	50% (Median split)	Mean # of correct comprehension questions (range 0-3) % choosing higher quality hospital	Symbols vs. Numbers: Overall: Comprehension: NR, NS Choice: +14%, ($P < 0.05$) High Numeracy Subgroup: Comprehension: NR Choice: +18%[a], NR Low Numeracy Subgroup: Comprehension: NR Choice: -5%[a], NR p for interaction by numeracy: Comprehension: ($P < 0.001$) Choice: NR Colored vs. B & W symbols: Overall: Comprehension: NR Choice: +3%[a], NS High Literacy Subgroup: Comprehension: NR Choice: = 16%[a], ($P < 0.05$) Low Literacy Subgroup: Comprehension: NR Choice: -11% [a], NS

[a]Calculated by research team

B & W symbols, black and white symbols; CI, confidence interval; NOS, not otherwise specified; NR, not reported; NS, not significant; OR, odds ratio; Quasi-, quasi-experimental study;RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; vs., versus.

Table 50. Single intervention strategies: Additive and alternative pictorial representation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Peters et al., 2007[130] (Study 2) (continued)							Death rate with B&W symbols: High Literacy Subgroup: +12%, NR Low Literacy Subgroup: +11%, NR Death rate with traffic light symbols: High Literacy Subgroup: +29%, NR Low Literacy Subgroup: +6%, NR Death rate/non-pertinent info with B&W symbols: High Literacy Subgroup: +7%, NR Low Literacy Subgroup: -9%, NR Death rate/non-pertinent with traffic light symbols: High Literacy Subgroup: +22%, NR Low Literacy Subgroup: -26%, NR p for interaction (pertinent vs. non-pertinent): choice: ($P < 0.05$) p for interaction (literacy level): ($P < 0.05$)

Table 50. Single intervention strategies: Additive and alternative pictorial representation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Peters et al., 2007[130] (Study 3) Fair	RCT	Lower is better, no symbols	1) higher is better, no symbols 2) lower is better, symbols 3) higher is better, symbols	303	50% (score < 10 on DR Numeracy Test)	Mean # correct responses to comprehension questions (range 0-4) % choosing higher quality hospital	Symbols vs. No Symbols: Comprehension: Overall: NR, $P < 0.10$ High Literacy Subgroup: -0.3*, ($P < 0.05$) Low Literacy Subgroup: -0.1[a], NR Choice: Higher Literacy Subgroup: -7[a], NR Lower Literacy Subgroup: +0.5[a], NR Higher # better, no symbols vs. Control: High Literacy Subgroup: Comprehension: +0.3, NR Choice: -4% Low Literacy Subgroup: Comprehension: +0.3, NR Choice: +26%, ($P < 0.05$) Lower # better + symbols vs. Control: High Literacy Subgroup: Comprehension: -0.2, NR Choice: -19% Low Literacy Subgroup: Comprehension: -0.2, NR Choice: +12%, NR

Table 50. Single intervention strategies: Additive and alternative pictorial representation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Peters et al., 2007[130] (Study 3) (continued)							Higher # better + symbols vs. Control: High Literacy Subgroup: Comprehension: -0.1, NR Choice: +1% Low Literacy Subgroup: Comprehension: +0.5, NR Choice: +25%, ($P < 0.05$)
Wright et al., 2009[128] Fair	RCT	Dispersed dot display (3 different risk magnitudes: 3%, 6%, 50%)	Grouped dot display (3 different risk magnitudes: 3%, 6%, 50%)	140	41% Low (incorrect answer to 1st question on Lipkus numeracy scale)	% correctly identifying largest of 3 displayed risks	Grouped vs. dispersed format (OR comprehension): 2.26 (0.779 to 6.57) [a] Comprehension with grouped display (OR high vs. low numeracy): 3.830 (95% CI, 1.301-11.280) Comprehension with dispersed display (OR high vs. low numeracy): 10.2, CI, NR Interaction term (display by numeracy): NS
Walker et al., 2007[101] Fair	RCT	Standard Arthritis Booklet	Standard Arthritis booklet + Mind Map	363	15% REALM < 60 (9th grade)	Mean Rheumatoid Arthritis Knowledge Score (range -40 to 40)	Overall: 0.91, ($P > 0.3$) Note: REALM score predicts change in knowledge, ($P < 0.003$)

Table 50. Single intervention strategies: Additive and alternative pictorial representation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Mayhorn and Goldsworthy, 2007[131] Fair	Quasi-(post only)	Original teratogen symbol (slash through pregnant woman)	1) Original symbol, but woman taking pill 2) Cross and skull bones in pregnant belly 4) 2 pictures: Original symbol + skull bones in pregnant belly 5) 2 pictures: #4 but more caricatured 6) 1 picture combining original symbol + skull bones in pregnant belly 7) skull bones in pregnant belly + inlay with slash through person taking pills	700	42.9% Low literacy (REALM, NOS)	% Who correctly identify symbol meaning as “don’t take if pregnant” % Who correctly identify symbol as “causes birth defect”	"Don't take if pregnant" (x versus original symbol 3) Symbol 1 +4%, NR Symbol 2: -8%, NR Symbol 4: +3%, NR Symbol 5: +8%, NR Symbol 6: -29%, NR Symbol 7: -10%, NR "Causes birth defects" (x versus original symbol 3) Symbol 1: -1%, NR Symbol 2: +14%, NR Symbol 4: +19%, NR Symbol 5: +14%, NR Symbol 6: +4%, NR Symbol 7: +15%, NR Note: addition of text that says “causes birth defects” increase understanding for all

Table 50. Single intervention strategies: Additive and alternative pictorial representation (continued)

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Hwang et al., 2005[137] Fair	Quasi-(post-post)	Medication label text: A. Take with water B. May cause drowsiness C. Take with food D. No alcohol E. Take on an empty stomach	Medication label text + illustration	130	5% REALM ≤ 6th grade 22% REALM 7th-8th grade	% correctly interpreting prescription label	Change in Interpretation of Label B with illustration: Improved: 5 No Change: 87% Worse: 9% (*P* = 0.33) Change in Interpretation of Label E with illustration Improved: 7% No Change: 86% Worse: 7% (*P* = 1.00) Note: change in interpretation of labels A, C, D = 0

Table 51. Single intervention strategies: Alternative media

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Sizes	% Population Limited Literacy	Outcomes	Difference
Campbell et al., 2004[142] Fair	RCT	Standard print consent form	(1) Simplified print consent form (2) Video consent (3) Computerized consent	233	50% Low (≤ 8th grade reading level on Woodcock Johnson) Average REALM score 56.3	% of total information remembered on free recall % of correct answers on prompted recall	% of total information remembered on free recall: simplified vs. standard: +0.1%, NS video vs. standard: 0.1% < NS computer vs. standard: -0.1%, NS Note: no interaction by literacy level % correct answers on prompted recall: simplified vs. standard: +6%, NS Note: trend toward improvement in low literacy group video vs. standard: +3%, NS computer vs. standard: +4%, (P = 0.08)

NS, not significant; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; vs., versus.

Table 52. Single intervention strategies: Alternative readability and document design

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population with Limited Literacy	Outcomes	Difference
Sudore et al., 2006[134] Fair	Quasi-(post only)	None	Simplified consent form	204	22% TOFHLA Inadequate 18% TOFHLA Marginal	# of passes through the teach-to-goal consent process required to obtain consent # of comprehension statements missed on the first pass of questioning	Overall # of passes through teach to goal: 1: 28% 2: 53% 3: 20% P for literacy interaction: 0.02; those with inadequate literacy 25% more likely to require > 1 pass # of comprehension statements missed on first pass questioning: 0: 28% 1: 30% 2 or more: 42%
Coyne et al., 2003[141] Fair	RCT	Standard Consent Form	Simplified consent form	44 oncology groups 226 patients	Mean REALM: 65	% of answers correct to 23 comprehension questions (note also measured decision to participate)	Overall: 3%, (*P* = 0.21)
Sudore et al., 2007[146] Sudore et al., 2008[150] Fair	RCT	Standard Advanced Directive	Simplified Advanced Directive	205	40% TOFHLA < 22 (Inadequate or Marginal)	knowledge of advance directive topics, advance directive completion at 6 months Note: also measure % of form completed	Knowledge (adjusted for baseline knowledge): +1%, p = 0.30 Advance directive completed at 6 months (unadjusted): +11%, (*P* = 0.03)
Yates and Pena, 2006[133] Fair	RCT	Standard head trauma advice form	Simplified head trauma advice form	200	1.5% REALM < 7th grade[a] 14% REALM 7th-8th grade[a]	Mean comprehension score (range 0-10)	Median score: +1 correct: (*P* < 0.0001) OR comprehension (simplified versus std): 4.14 (2.19 - 7.81) No interaction by literacy level

[a]Read from table

OR, odds ratio; Quasi-, quasi-experimental study; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; std, standard; TOFHLA, Test of Functional Health Literacy in Adults.

Table 53. Single intervention strategies: Physician notification of patient literacy levels[a]

Author, Date of Publication, Quality	Study design	Control	Intervention	Sample Size	% Population Limited Literacy	Outcomes	Difference
Seligman et al., 2005[124] Fair	cRCT	Usual Care for Diabetes	Physician notification of patients' health literacy status	63 MDs 182 pts	74% TOFHLA Inadequate 16% TOFHLA Marginal	% of physicians reporting use of > 3 communication enhancing strategies Mean patient Self-efficacy using Patient Enablement Instrument (range 0-12) Mean HgbA1c	% physicians with intensive use of communication strategies (adjusted OR): 4.7, 95% CI, 1.4-16.0 Note: trends toward differences for individual communication strategies of involving family/friends and referring to a nutritionist Patient Self-efficacy (adjusted): -0.3, (*P* = 0.61) HbA1c (adjusted): -0.27, 95% CI, -0.80-0.27

[a]Communication strategies include Involving family members or friends; referring to a nutritionist; using pictures of diagrams; referring to a diabetes educator; reviewed understanding of medications; spending time teaching about diabetes

CI, confidence interval; cRCT, cluster randomized controlled trial; HgbA1c, glycosylated hemoglobin; MDs, medical doctors; OR, odds ratio; pts, patients; TOFHLA, Test of Functional Health Literacy in Adults.

Table 54. Effect of mixed interventions on use of health care services

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Murray et al., 2007[125] Good	RCT	Usual Care	CHF Adherence Intervention	314	29% "not literate" on sTOFHLA (NOS)	ED visit Hospitalization	ED visits: Absolute difference(unadjusted): -0.52, NR incidence rate ratio (unadjusted): 0.82 (0.70 to 0.95) Hospitalizations: absolute difference (unadjusted): -0.21, NR incidence rate ratio (unadjusted): 0.81 (95%, CI 0.64-1.04)
Gerber et al., 2005[136] Fair	RCT	Usual Care + computerized quizzes on diabetes-related concepts	Diabetes Self-Management Intervention	144	56% sTOFHLA < 22 (Inadequate or marginal)	Receipt of Recommended Medical Services (NOS)	Low Literacy Subgroup: Change Medical Care: -0.29, NS High Literacy Subgroup: Change Medical Care: -0.07, NS
Robinson et al., 2008[149] Fair	Quasi (pre-post)	NA	Asthma Self-Management Intervention	110	Mean Gilmore Oral Reading Test Score: 3.2	Asthma-related ED visits: Asthma-related hospitalizations:	ED visits (unadjusted): - 29.6%, (P < 0.01) Interaction by literacy subgroup: OR for Effect of reading level on ER visits: 0.34 (0.22 - 0.52) Hospitalizations (?adjusted): -14.9%, (P < 0.001), no interaction

[a] any CRC screening test includes home fecal occult blood testing, sigmoidoscopy, and colonoscopy

CHF, congestive heart failure; CI, confidence interval; CRC, colorectal cancer; cRCT, cluster randomized controlled trial; DRE, digital rectal examination; ED, emergency department; IRR, incidence rate ratio; MDs, medical doctors; NA, not applicable; NOS, not otherwise specified; NR, not reported; NS, not significant; OR, odds ratio, ER, emergency room; PSA, prostate specific antigen; pts, patients; Quasi, quasi-experimental study; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; sTOFHLA, short form Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults

Table 54. Effect of mixed interventions on use of health care services (continued)

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
DeWalt et al., 2006[144] Fair	RCT	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	127	41% sTOFHLA inadequate	Hospitalization	Hospitalization or death: Overall: IRR (unadjusted) = 0.69 (95% CI,, 0.40-1.19) Inadequate literacy subgroup: IRR (adjusted) = 0.39 (95% CI, 0.16-0.91) Marginal/adequate literacy subgroup: IRR (adjusted) = 0.56 (95% CI, 0.30-1.04)
Kripalani et al., 2007[145] Fair	RCT	Handout, NOS Unclear if prostate content or other content	1) Educational Intervention on Prostate Cancer Screening 2) Cue to Discuss Prostate Cancer screening	303	38% REALM < 3rd grade 18% REALM 4th-6th grade 23% REALM 7th-8th grade	PSA test ordered DRE documented	Education PSA test ordered (adjusted OR): 7.62; CI, 1.62-35.83 DRE documented (adjusted OR): 0.85; CI 0.21-3.37 Cue PSA test ordered (adjusted OR): 5.86; CI, 1.24-27.81 DRE documented (adjusted OR): 1.04; CI, 0.29-3.76
Ferreira et al., 2005[138] Fair	cRCT	Usual Care	Educational Intervention for Physicians and Patients on Colorectal Cancer screening	113 MDs 1978 pts	31% Low (< 9th grade on TOFHLA) Note: measured only in 19% of patients	% of patients for whom any CRC screening test[a] is recommended in 18 months following visit % of patients for whom screening is completed within x timeframe	Difference in Any Recommendations: Overall: 6.6%, (*P* = 0.02) Literacy subgroup results NR Difference in Completion of Any Tests: Overall: 8.9%, (*P* = 0.003) Low Literacy Subgroup: 25.7%, (*P* = 0.002) High Literacy Subgroup: 3%, 0.65

Table 55. Effect of mixed interventions on knowledge

Author, Date of Publication, Quality	Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference Between Control and Intervention Groups
Gerber et al., 2005[136] Fair	RCT	Usual Care + compute-rized quizzes on diabetes-related concepts	Diabetes Self-Management Intervention	144	56% sTOFHLA < 22 (Inadeq. or marginal)	Mean Change in Diabetes Knowledge (scale NR)	Low Literacy Change Knowledge: -0.12, NS High Literacy Change Knowledge: +0.3, NS
Wallace et al., 2009[153] Fair	Quasi-(pre-post)	NA	Diabetes Self-Management Intervention	250	29% TOFHLA inadeq. 14% TOFHLA marginal	% of Diabetes Knowledge questions correct	Overall: 6.16, (P = 0.33)
Kim et al., 2004[139] Fair	Quasi-(pre-post)	None	Diabetes Self-Management Intervention	92	23% sTOFHLA < 22 (Inadeq. or marginal) (15% inadeq. on TOFHLA)	% Diabetes Knowledge Questions Correct	Overall (adjusted): NR, sig Adeq. vs. Inadeq. HL (adjusted): NR (+), (P < 0.001)
DeWalt et al., 2006[144] Fair	RCT	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	127	41% sTOFHLA inadeq.	% CHF Knowledge questions correct	Overall: 12% (95% CI, 6-18%)
Brock and Smith, 2007[154] Fair (although poor for adherence)	Quasi-(pre-post)	NA	Adherence Video on PDA	51	55% REALM < 8th grade	Mean HIV and HIV medication Knowledge (9-pt. scale)	Overall: NR, (P < 0.005)

[a]Determined through personal communication with author

9-pt. scale, 9-point scale; MD recs., physician's recommendations; Adeq., Adequate; CHF, congestive heart failure; CI, confidence interval; HIV, human immunodeficiency virus; HL, health literacy; Inadeq, inadequate; NA, not applicable; NR, not reported; NS, not significant; PDA, personal digital assistant; Quasi-, quasi-experimental study; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; sig, significant; sTOFHLA, short form Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults.

Table 55. Effect of mixed interventions on knowledge (continued)

Author, Date of Publication, Quality	Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference Between Control and Intervention Groups
Bosworth et al., 2005[143] Fair	RCT	Usual Care	Tailored Adherence Intervention	588	38% low literacy[a]	Mean Change in Hypertension knowledge (score range 0 - 10)	Overall: 0, (*P* = 0.49)
Paasche-Orlow et al., 2005[83] Fair	Quasi-(pre-post)	NA	Asthma Self-Management Intervention	73	22% sTOFHLA Inadeq.	% Mastering discharge medication regimen after one round of teaching	Overall (unadjusted): + 20%, NR; p for interaction by literacy: (*P* = 0.40)
Davis et al., 2008[147] Fair	Quasi-(pre-post)	None	Weight loss intervention	101	49% REALM < 6th grade 22% REALM 7th-8th grade	Patient recall of MD recs. to lose weight, increase physical activity or see a dietician	Patient recall of recommendations: Lose weight +43%, (*P* = 0.02) Increase physical activity +41%, (*P* = 0.01) Go to dietician +39%, (*P* = 0.002)
Kripalani et al., 2008[148] Fair	Quasi-(post only)	No control	1) Modified Print informed Consent with Oral Overview	408	21% REALM $\leq$ 3rd grade 25% REALM 4th - 6th grade 31% REALM 7th - 8th grade	Odds of correctly teaching back consent and HIPAA information on first attempt (relative to those with literacy level $\leq$ 3rd grade	Correct teach back 1st attempt by literacy subgroup: 4th - 6th grade - 2.259 (1.048-4.869) 7th - 8th grade - 2.275 (1.049-4.935) $\geq$ 9th grade - 4.344 (1.814-10.404)

Table 56. Effect of mixed interventions on self-efficacy

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Gerber et al., 2005[136] Fair	RCT	Usual Care + computerized quizzes on diabetes-related concepts	Diabetes Self-Management Intervention	144	56% sTOFHLA < 22 (Inadeq. or marginal)	Change in Mean Diabetes Self-efficacy – (score range NR)	Low Literacy Change Self-efficacy: +0.52, 0.113 High Literacy Change Self-efficacy: -0.20, NS
Schillinger et al., 2008[129]; Schillinger et al., 2009[152] Fair	RCT	usual care	1) Diabetes Self Management Program (automated telephone delivery) 2) Diabetes Self-Management Program (group medical visit delivery)	339	59% sTOFHLA ≤ 22 (inadeq. or marginal)	Mean Diabetes self-efficacy (0 - 100 scale)	ATSM-Usual Care (adjusted): 6.0 (2.0 to 10.1) GMV-Usual Care (adjusted) : 5.5 (1.4 to 9.6) ATSM-GMV (adjusted): 0.5 (-3.6 to 4.6)
Dewalt et al., 2009[181] Wallace et al., 2009[153] Fair	Quasi- (pre-post)	NA	Diabetes Self-Management Intervention	250	29% TOFHLA inadeq. 14% TOFHLA marginal	Mean diabetes self-care self-efficacy (0–100 scale)	Overall (unadjusted): 1.13, (P = 0.29)
DeWalt et al., 2006[144] Fair	RCT	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	127	41% sTOFHLA inadeq.	Mean difference in CHF self-efficacy (range of scores 0-24)	Overall: 2 (95% CI, 0.7-3.1)
Kripalani et al., 2007[132] Fair	Quasi- (pre-post)	None	CHD adherence intervention (pill card)	242	42% REALM ≤ 6th grade 37% REALM 7th-8th grade	Mean Self Efficacy for Appropriate Medication Use Scale (score range 13-39)	Overall: +2.5, NR

ATSM, automated telephone self-management support; CHD, coronary heart disease; CHF, congestive heart failure; CI, confidence interval; GMV, group medical visits; Inadeq., inadequate; mo., month; NA, not applicable; NR, not reported; NS, not significant; quasi-, quasi-experimental study; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; sTOFHLA, short form Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults.

Table 56. Effect of mixed interventions on self-efficacy (continued)

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Rudd et al., 2009[151] Fair	RCT	Arthritis Management Intervention (arthritis pamphlet, medicine calendar, hospital map)	Arthritis Management Intervention + Individual Counseling	127	19% REALM ≤ high school	Mean self-efficacy (score range 1-4)	Overall at 12 mo. (adjusted): NR, (P = 0.12)
Robinson et al., 2008[149] Fair	Quasi-(pre-post)	NA	Asthma Self-Management Intervention	110	Mean Gilmore Oral Reading Test Score: 3.2	Mean Asthma Self Efficacy Scale (scale 40-100)	Overall (unadjusted): 10.4, (P < 0.001)
Davis et al., 2008[147] Fair	Quasi-(Pre-post)	None	Weight loss intervention	101	49% REALM < 6th grade 22% REALM 7th-8th grade	% patients reporting confidence in ability to lose weight	Overall: +27%, (P = 0.01)

Table 57. Effect of mixed interventions on behavior

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Schillinger et al., 2008[129]; Schillinger et al., 2009[152] Fair	RCT	Usual Care	1) Diabetes Self Management Program (automated telephone delivery) 2) Diabetes Self-Management Program (group medical visit delivery)	339	59% sTOFHLA ≤ 22 (inadequate or marginal)	Mean # of days self care behavior performed in last 7 days (score range 0-7) Mean # minutes engaged in moderate or vigorous physical activity/week	Overall # self-care days: ATSM-Usual Care (adjusted): 0.6 (0.4 to 0.9) GMV-Usual Care (adjusted): 0.3 (0.01 to 0.6) ATSM-GMV (adjusted): 0.3 (0.1 to 0.6) Minutes of moderate physical activity: ATSM-Usual Care (adjusted): 123.9 (14.8 to 233.0) GMV-Usual Care (adjusted): 69.1 (-42.1 to 179.4) ATSM-GMV (adjusted): 54.8 (-62.1 to 186.3) Minutes of vigorous physical activity: ATSM-Usual Care (adjusted): 32.2 (-9.8 to 74.2) GMV-Usual Care (adjusted): 23.3 (-19 to 65.5) ATSM-GMV (adjusted): 8.9 (-33.7 to 51.5)

Adeq., adequate; ATSM, automated telephone self-management support; CHF, congestive heart failure; GMV, group medical visits; HL, health literacy; NR, not reported; Quasi, quasi-experimental study; RCT, randomized controlled trial; sTOFHLA, short form Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults.

Table 57. Effect of mixed interventions on behavior (continued)

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Kim et al., 2004[139] Fair	Quasi-(Pre-post)	None	Diabetes Self-Management Intervention	92	23% sTOFHLA < 22 (Inadequate or marginal) (15% inadequate on TOFHLA)	# self-care days in last 7 days	Overall (adjusted): NR, sig Adeq. vs. Inadeq. HL (adjusted): Diet: NR, (P < 0.001) Exercise: NR, (P = 0.022) Foot care: NR, (P = 0.001) Medication adherence: NR, (P = 0.751) Self-glucose monitoring: NR, (P = 0.002)
DeWalt et al., 2006[144] Fair	RCT	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	127	41% sTOFHLA inadequate	% weighing daily at 12 months	Overall: NR, (P < 0.001)

Table 58. Effect of mixed interventions on adherence

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% population with Limited Literacy	Outcome	Difference
Murray et al., 2007[125] Good	RCT	Usual Care	CHF Adherence Intervention	314	29% "not literate" on sTOFHLA (NOS)	% of prescribed medication taken (according to MEMS cap)	% of prescribed medication taken: During intervention (unadjusted): +10.9% (95% CI, 5%-16.7%) Post Intervention (unadjusted): +3.9% (-2.8%-10.7%)
Bosworth et al., 2005[143] Fair	RCT	Usual care	Tailored Adherence Intervention	588	38% low literacy[a]	Change in % reporting agreement to any question in Morisky adherence scale	Overall change: 0.007% (95% CI, -0.62%-0.076%) Change among those initially adherent: -2%, (*P* = 0.68) Change among those initially non-adherent: +12%, (*P* = 0.08)
Paasche-Orlow et al., 2005[83] Fair	Quasi-(pre-post)	NA	Asthma Self-Management Intervention	73	22% sTOFHLA Inadequate	% with adherence less than 50% for inhalers or meds (according to Doser CT or MEMS cap)	Poor adherence, by literacy subgroups (adjusted): NR, p for interaction: (*P* = 0.45)
Kim et al., 2004[139] Fair	Quasi-(pre-post)	None	Diabetes Self-Management Intervention	92	23% sTOFHLA < 22 (Inadequate or marginal) (15% inadequate on TOFHLA)	# days of Medication adherence in last week	Overall: +0.7[b], NR Adeq. vs. Inadequate HL (adjusted): NR, (*P* = 0.751)

[a]Determined through personal communication with author; [b]Calculated by team

Adeq., adequate; CHF, congestive heart failure; HL, health literacy; meds, medications; MEMS cap, Medication Event Monitoring System cap; NA, not applicable; NOS, not otherwise specified; NR, not reported; Quasi-, quasi-experimental study; RCT, randomized controlled trial; sTOFHLA, short form Test of Functional Health Literacy in Adults; vs., versus.

Table 59. Effect of mixed interventions on disease prevalence and severity

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Gerber et al., 2005[136] Fair	RCT	Usual Care + computerized quizzes on diabetes-related concepts	Diabetes Self-Management Intervention	144	56% sTOFHLA < 22 (Inadequate or marginal)	Mean Change in Hemoglobin A1C Mean Change in Systolic and Diastolic Blood Pressure (mmHg) Mean Change in Body Mass Index (kg/m^2)	Low Literacy Subgroup: Change in HgbA1C: -0.1, NS Change in SBP: -1 mmHg, NS Change in DBP: 3 mmHg, NS Change in BMI: NR, NS High Literacy Subgroup: Change in HgbA1C: 0.0, NS Change in SBP: +1 mmHg, NS Change in DBP: -7 mmHg, NS Change in BMI: -1 kg/m^2, NS Note: in exploratory subgroup analyses of Hgba1c > 9 (n = 26), intervention more effective than control for low literacy (but not high literacy) group
Rothman et al., 2004[140] Fair	Quasi - (Pre-post)	NA	Diabetes Disease Management Intervention	159	55% Lower Literacy 32% REALM ≤ 3rd grade 23% REALM Score 4th-6th grade	Mean HgbA1c	Lower Literacy Subgroup (unadjusted): -1.9% points (95% CI, -2.5 to -1.2) Higher Literacy Subgroup (unadjusted): -1.8% points (95% CI, -2.5 to -1.0)

[a]Calculated by team

Adeq., adequate; ATSM, automated telephone self-management support; BMI, body mass index; CI, confidence interval; DBP, diastolic blood pressure; GMV, group medical visit-usual care; HgbA1c, glycosylated hemoglobin; NA, not applicable; NR, not reported; NS, not significant; Quasi-, quasi-experimental study; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; SBP, systolic blood pressure; sTOFHLA, short form Test of Functional Health Literacy in Adults; TOFHLA, Test of Functional Health Literacy in Adults; vs., versus, HL, health literacy.

Table 59. Effect of mixed interventions on disease prevalence and severity (continued)

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Schillinger et al., 2008[129]; Schillinger et al., 2009[152]	RCT	Usual Care	1) Diabetes Self Management Program (automated telephone delivery) 2) Diabetes Self-Management Program (group medical visit delivery)	339	59% sTOFHLA ≤ 22 (inadequate or marginal)	Mean Hemoglobin A1C Mean Systolic and diastolic blood pressure (mmHg) Mean Body Mass Index (kg/m^2)	HgbA1C ATSM-Usual Care (adjusted): -0.1 (-0.5 to 0.4) GMV-Usual Care (adjusted): 0.2 (-0.2 to 0.7) ATSM-GMV (adjusted): -0.3 (-0.8 to 0.7) SBP ATSM-Usual Care (adjusted): -3.2 mmHg (-8.3 to 1.9 mmHg) GMV-Usual Care (adjusted): -3.9 mmHg (-9.0 to 1.2 mmHg) ATSM-GMV(adjusted): 0.7 mmHg (-4.5 to 5.9 mmHg) DBP ATSM-Usual Care(adjusted): -1.6 mmHg (-5.1 to 2.0 mmHg) GMV-Usual Care (adjusted): -3.1 mmHg (-6.6 to 0.4 mmHg) ATSM-GMV (adjusted): 1.5 mmHg (-2.0 to 5.1 mmHg) BMI ATSM-Usual Care (adjusted): 0.1 kg/m2 (-0.4 to 0.5 kg/m^2) GMV-Usual Care (adjusted): 0.02 kg/m2 (-0.5 to 0.5 kg/m^2) ATSM-GMV (adjusted): 0.1 kg/m^2 (-0.4 to 0.5)

Table 59. Effect of mixed interventions on disease prevalence and severity (continued)

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Kim et al., 2004[139] Fair	Quasi-(pre-post)	None	Diabetes Self-Management Intervention	92	23% sTOFHLA < 22 (Inadequate or marginal) (15% inadequate on TOFHLA)	Mean HgbA1c	Overall (unadjusted): -0.13[a], Sig Adeq. vs. Inadeq. HL (adjusted): NR, (*P* = 0.086)
Rothman et al., 2004[126] Good	RCT	1-hour education session	Diabetes Disease Management Intervention	217	38% REALM ≤ sixth grade	Mean HgbA1c Systolic blood pressure	Overall: SBP -7.6 mmHg (-13 to -2.2 mmHg) Low literacy subgroup: HgbA1c (adjusted): -1.4%; 95% CI, -2.3% to -0.6%) High literacy subgroup): HgbA1c (adjusted): -0.5%; 95% CI, -1.4%-0.3%
Paasche-Orlow et al., 2005[83] Fair	Quasi-(pre-post)	NA	Asthma Self-Management Intervention	73	22% sTOFHLA Inadequate	% with better than mean score on asthma symptom questionnaire	Overall: NR By subgroup: NR p for interaction: (*P* = 0.84)
Weiss et al., 2006[135] Fair	RCT	Usual care	Adult Basic and Literacy Education (ABLE)	70	Mean REALM score 47	Mean depression severity score on Patient Health Questionnaire (score range 0-27)	Overall (unadjusted): 1st follow-up: 0, P = 0.25 2nd follow-up: -3, P = 0.03 3rd follow-up: -4, P = 0.04 Note baseline difference in REALM

Table 60. Effect of mixed interventions on quality of life

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% population with Limited Literacy	Outcome	Difference
Schillinger et al., 2008;[129] Schillinger et al., 2009[152]	RCT	Usual Care	1) Diabetes Self Management Program (automated telephone delivery) 2) Diabetes Self-Management Program (group medical visit delivery)	339	59% sTOFHLA ≤ 22 (inadequate or marginal)	SF12-Mental health scale (score range 0 - 100) SF-12 Physical health scale (score range 0-100) Mean # days in bed in last month due to health problems Extent to which diabetes limits normal activity (score range 0 - 5, lower = less)	SF-12 mental health: ATSM-Usual Care (adjusted): 3.7 (-2 to 9.4) GMV-Usual Care (adjusted): -2.9 (-8.6 to 2.9) ATSM-GMV (adjusted): -6.5 (0.7 to 12.4) SF-12 physical health: ATSM-Usual Care (adjusted): 2.7 (-4.0 to 9.5) GMV-Usual Care (adjusted): -0.1 (-6.9 to 6.7) ATSM-GMV(adjusted): 2.9 (-4 to 9.7) # Bed Days over prior month: ATSM-Usual Care (adjusted): -1.7 (-3.3 to -0.1) GMV-Usual Care(adjusted): 0.6 (-1.0 to 2.2) ATSM-GMV (adjusted): -2.3 (-3.9 to -0.4) Extent limited activity: ATSM-Usual Care: NR, (*P* = 0.02) GMV-Usual Care: NR, NS ATSM-GMV: NR, NS

ATMS, automated telephone self-management support; CHF, congestive heart failure; CI, confidence interval; GMV, group medical visits; HAQ, the Health Assessment Questionnaire; MLHF, the Minnesota Living with Heart Failure Questionnaire; NOS, not otherwise specified; NR, not reported; NS, not significant; RCT, randomized controlled trial; REALM, Rapid Estimate of Adult Literacy in Medicine; SF-12 Mental health scale, 12-item short-form mental health scale; sTOFHLA, short form Test of Functional Health Literacy in Adults.

Table 60. Effect of mixed interventions on quality of life (continued)

Author, Date of Publication, Quality	Study Design	Control Group	Intervention	Sample Size	% population with Limited Literacy	Outcome	Difference
Murray et al., 2007[125] Good	RCT	Usual Care	CHF Adherence Intervention	314	29% "not literate" on sTOFHLA (NOS)	Mean score on Chronic Heart Failure Questionnaire (range from 1 to 7; better functioning = higher)	Within Intervention Group (unadjusted): +0.39
DeWalt et al., 2006[144] Fair	RCT	Usual Care + low literacy pamphlet on CHF	CHF Self-Management program	127	41% sTOFHLA inadequate	CHF related Quality of Life by MLHF (range of scores 0-105)	Heart failure-related quality of life (adjusted): 2 (95% CI, 9 to -5)
Rudd et al., 2009[151] Fair	RCT	Arthritis Management Intervention (arthritis pamphlet, medicine calendar, hospital map)	Arthritis Management Intervention + Individual Counseling	127	19% REALM ≤ high school	HAQ scores (range of scores 0 - 3, 0 best)	Mean change in HAQ scores at 12 months: -0.79, (P = 0.64)

Table 61. Effect of mixed interventions on health care costs

Author, Date of Publication, Quality	Study design	Control Group	Intervention	Sample Size	% Population with Limited Literacy	Outcome	Difference
Murray et al., 2007[125] Good	RCT	Usual Care	CHF Adherence Intervention	314	29% "not literate" on sTOFHLA (NOS)	Total intervention, outpatient, and inpatient costs	-$2960 (95% CI, -$7603-$1338)

CHF, congestive heart failure; CI, confidence interval; NOS, not otherwise specified; RCT, randomized controlled trial; sTOFHLA, short form Test of Functional Health Literacy in Adults.

Chapter 5. Discussion

Overview

During this systematic review update, the RTI-UNC EPC identified a moderately large body of literature addressing the relationship between health literacy (including numeracy) and health outcomes. Our two main key questions (KQs) and subquestions were

1. Outcomes: Are health literacy skills related to (a) use of health care services, (b) health outcomes, (c) costs of health care, and (d) disparities in health outcomes or health care service use?
2. Interventions: For individuals with low health literacy skills, what are effective interventions to (a) improve use of health care services, (b) improve health outcomes, (c) affect the costs of care, and (d) improve health care service use and/or health outcomes among different racial, ethnic, cultural or age groups?

These issues parallel the questions addressed in the initial review, published in 2004.[1,27,28]

The amount of research being published in the field has expanded substantially. The initial review was limited to the relationship between literacy and health outcomes (or interventions); it included a total of 73 articles, 44 addressing outcomes and 29 addressing interventions. This review expanded the scope of studies; it included 103 new good or fair studies reported in a total of 112 unduplicated articles. Of these, 81 articles addressed the relationship between health literacy and outcomes and 13 of which examined the relationship between numeracy and outcomes. In addition, 33 articles reported on interventions for individuals with low health literacy, split between those testing a single intervention strategy and those testing a mix (combination) of intervention strategies.

In this chapter, we recap the principal findings for KQ 1 and KQ 2, and comment on the applicability of the available bodies of evidence. We then discuss the limitations of both the literature reviewed and our own update. Finally, we present recommendations for future research.

Principal Findings

KQ 1: Health Literacy and Outcomes

Literacy studies. For examining the association between health literacy and health outcomes (KQ 1), we included 81 fair or good quality articles (68 studies) in this update. Of these, 23 articles addressed the effect on health care service use, 58 on health outcomes, 6 on disparities, and 2 the effect on costs. Overall, the majority of studies were assessed as being of fair quality.

Differences in health literacy level were associated with use of health care services. Specifically, lower literacy was associated with increased emergency department and hospital use, less screening for cervical cancer (through a Papanicolau test [Pap smear]) and breast cancer (mammography) and lower influenza immunization. Evidence was mixed for pneumococcal immunization and access to office visits. The evidence to support these findings was moderate for hospitalizations, emergency department visits, and influenza immunization. Evidence for

other health care service use was low or moderate because of inconsistent findings and outcomes.

The effect of health literacy on health outcomes was variable. The risk of mortality for seniors was clearly higher with lower health literacy. There was also moderate evidence to support a relationship between lower health literacy and poorer ability to interpret labels and health messages, higher mental health prevalence and related outcomes, and poorer overall health status among seniors. In these studies, the evidence consists of all observational studies, generally having a medium risk of bias and results generally in a consistent direction. The evidence for all other outcomes was either low or insufficient because the literature consisted of a small number of studies, poorly designed studies, and/or inconsistent results. These evaluations focused on the relationship between the lowest health literacy group and the highest. The evidence was sparse for evaluating differences between those with marginal (a middle category) health literacy and adequate (the highest category).

The evidence concerning differences by health literacy level in costs of health care (KQ 1c) was low. The two relevant studies examined different payment sources (Medicaid and Medicare), found inconsistent results, and included different patient populations. No studies examined differences in costs among those with private health insurance coverage or no coverage.

Health literacy mediates the relationship between back race and health for a variety of outcomes. Outcomes studied included a condition that keeps you from work or having a long term illness, self-reported health status, receipt of an influenza vaccine among seniors, physical and mental health-related quality of life, self reported health among seniors, prostate-specific antigen levels among newly diagnosed prostate cancer patients, and nonadherence to HIV medications. We cannot know whether health literacy level would also be a mediator of the relationship between black race and other health outcomes that have not been tested. Only one study examined whether health literacy level mediated the relationship between race and health outcomes for persons of Hispanic ethnicity. We found no studies that evaluated the relationship between age, sex, cultural group, or other sociodemographic characteristics and health outcomes.

Numeracy studies. In this update, we reviewed 13 fair quality studies that examined the relationship between numeracy and various outcomes, including use of health care services, health outcomes, costs, and disparities. Most studies examining the relationship of numeracy to health outcomes were cross-sectional in design. Four studies were randomized controlled trials (RCTs) that analyzed their data in a cross-sectional manner for this analysis; and one used a prospective cohort design.

In general, the evidence for the relationship between numeracy and outcomes was insufficient or low given the small number of studies, which often had high levels of risk of bias or collectively gave us mixed results. Only two studies addressed the relationship between numeracy and use of health care services; results were mixed, likely due in part to a high risk of bias with lack of adjustment for relevant confounders in one study and inadequate power in the other. Similarly, several studies demonstrated that the relationships between numeracy level and accuracy of risk perception (5 studies), knowledge (4 studies), skills taking medication (2 studies), and disease prevalence and severity (3 studies) are mixed. However, evidence is emerging of a possible relationship between numeracy and disease-specific knowledge. Furthermore, lower numeracy level may lead to lower accuracy of perceived risk and treatment benefit, particularly if risk is presented over longer time frames (e.g., lifetime risks rather than 5-year risk) and if results reflect comparisons between those at the extremes of numeracy skill.

Evidence for the relationship between numeracy and other health outcomes (e.g. self-efficacy, behavior) was insufficient to draw conclusions. No studies addressed the costs associated with differences in numeracy level or whether numeracy level mediates health disparities.

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Literacy and numeracy studies. Four studies addressed the effects of both health literacy and numeracy on various outcomes.[8,62,65,118] Of these four studies, only two performed adjusted analyses on the same outcomes, thereby allowing assessment of whether these exposures affect health outcomes differently.[8,65] Rothman and colleagues showed that ability to read nutrition labels was lower in both those with low health literacy skills (less than ninth grade) measured by the Rapid Estimate of Adult Literacy in Medicine (REALM) and low numeracy skills (less than ninth grade) measured by the Wide Range Achievement Test for mathematics (WRAT-math).[8] However, they noted that the outcome was more highly correlated with numeracy (rho 0.67) than health literacy (rho 0.52). In contrast, Huizinga and colleagues found a relationship between numeracy (measured by the WRAT-math) and body mass index (BMI) but no relationship between literacy (measured by the REALM) and BMI.[65]

KQ 2. Interventions to Improve Health Literacy

In this update we identified 33 new fair or good quality studies addressing the effect of interventions designed to mitigate the effects of low health literacy. Fourteen used one specific strategy to mitigate the effects of low health literacy, and 19 used a mixture of strategies combined into one intervention.

Interventions with single design features. In general, the strength of evidence regarding the effect of specific design features of interventions for low health literacy populations is low. This is attributable, in large part, to differences in the interventions (and subsequently results) for studies broadly grouped in the following design feature categories: alternative document design, alternative numerical presentation, alternative pictorial representation.

Looking closely within categories, however, we noted that several specific design features show promise in improving comprehension for low health literacy populations. These features, each of which was tested in only one study, include presenting only essential information,[130] presenting essential information first,[130] presenting quality information with the higher number indicating better quality,[130] and presenting information in pictograms in grouped rather than random format.[128] Additionally, re-examining data from our 2004 review within these categories further suggests potential benefit from using reduced reading level, video, and/or illustrated narratives.[163,164,166,168-171,182] In contrast, one study raised questions about whether certain design features, such as colored traffic symbols to denote death rates in hospitals of varying quality or symbols accompanying nonessential quality information, may actually worsen health choices among those with low health literacy.[130]

Interventions with combinations of features. The strength of evidence for studies combining multiple strategies to mitigate the effects of low health literacy on outcomes was more variable that it was for single-feature interventions. We found consistent moderate strength of evidence that studied interventions change health care service use. Specifically, intensive self-management and adherence interventions appear to be effective in reducing emergency room visits and hospitalizations. Additionally, educational interventions and/or cues for screening increased colorectal cancer and prostate cancer screening. We note, however, that the health benefits of additional prostate cancer screening are questionable[183,184] and that increased screening rates could be a marker for poor decisionmaking.

We additionally found consistent evidence of moderate strength that some interventions change health outcomes. For instance, intensive disease-management programs appear to be effective at reducing disease prevalence and severity. Furthermore, self-management interventions increased self-management behavior; in studies that performed subgroup analyses, however, the effect was greater in high health literacy populations than in lower literacy populations. The effects of other interventions on other health outcomes, including knowledge, self-efficacy, and quality of life, were mixed; thus, the strength of evidence was low.

Components of effective interventions were their high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional. Interventions that changed distal outcomes appeared to work by intermediately increasing knowledge or self-efficacy, or by changing behavior.

Too few studies addressed the effects of literacy interventions on the outcomes of behavioral intent, health-related skills, cost, and disparities to draw any meaningful conclusions; the strength of evidence is low.

What this Update Adds to the Literature Included in the 2004 Review

Our results expand findings from our 2004 review in several ways. In the 2004 review, we recommended that future research examining the relationship between health literacy and health outcomes (KQ 1) consistently control for potential confounding variables to more accurately measure the strength of the relationship between health literacy and the outcome. Unlike the earlier review, in the update, primary study outcomes are generally evaluated using multivariate analysis and control for potential confounding variables, providing a better and less biased estimate of the direction and magnitude of effect for our findings. In 2004, we also recommended that studies more closely examine the factors that mediate the relationship

between health literacy and health outcomes. For the update, we found a limited body of research that begins to provide evidence of variables that may be on the pathway of effect between health literacy and health outcomes; these include factors such as knowledge, self-efficacy, and beliefs such as stigma related to their disease. We had not found any data on disparities for our earlier review. New studies suggest that health literacy can be a mediator of racial disparities in health outcomes. In 2004, we also recommended that studies stratify outcomes by numeracy level to gain a greater understanding of how these skills may uniquely affect health outcomes and under what conditions numeracy would be a useful indicator for targeting individuals for interventions. For the update, we found a small body of evidence concerning the relationship between numeracy level and health outcomes. This is not only useful in and of itself, but it also is the next step in expanding our understanding of the skills that are needed to be health literate.

For KQ 2, our findings also expand findings from the 2004 review in several ways. In the 2004 review, we recommended that additional and more varied studies of interventions be pursued and that all studies measure the interventions' effects in a broader range of outcomes and by literacy subgroup. Studies in the current report have largely addressed these recommendations.

First, they address more varied interventions and provide insights into the utility of particular intervention design features. In our 2004 report, there were relatively few interventions of any type. Thus, we focused on how interventions affected outcomes rather than attempting to parse interventions into specific elements. In the current report, we reviewed studies by the specific intervention design features studied; only when that was not possible (i.e. because interventions used multiple design features) did we review studies by the outcomes involved. Using this new organizational structure, we identified several promising intervention design features that bear further study, including several identified through our 2004 review; these include presenting only essential information,[130] presenting essential information first,[130] presenting quality information with the higher number indicating better quality,[130] presenting information in pictograms in grouped rather than random format,[128] and using reduced reading level, video, and/or illustrated narratives.[163,164,166,168-171,182] We also were able to illuminate what factors may be key in making the mixed interventions effective. Common features across nearly all of the mixed interventions that improved distal outcomes (e.g. self-management, hospitalizations, mortality) was their high intensity, theory basis, pilot-testing before full implementation, emphasis on skill building, and delivery of the intervention by a health professional (e.g., pharmacist, diabetes educator; see Table 47 in Chapter 4).[125,126,144,149]

Second, studies in the current report provide insight into the impact of interventions on a broader spectrum of outcomes. In our 2004 review, the majority of studies focused only on the outcome of knowledge. In the current review, studies focused on a broader range of outcomes, including disease self-efficacy, behavior, adherence, disease prevalence and severity, quality of life, preventive services use, ED visits, hospitalizations, and costs. Additionally, six studies in our update examined the impact of interventions on three or more[83,125,129,136,139,144] (see Table 46 in Chapter 4); they preliminarily suggest that effective interventions to mitigate the effects of low health literacy may work by increasing knowledge,[139,144] increasing self-efficacy,[129] or changing behavior.[125,129,139,144]

Third, nearly half of studies examined the effect of interventions by health literacy subgroup. This allows investigators to determine whether the intervention is more or less effective among those with low health literacy subgroup and whether interventions might ameliorate health disparities.

Limitations

Limitations of the Literature

Readers should interpret the findings from our systematic review in the context of several limitations. As with all systematic reviews, our results and conclusions depend on the quality of the published literature. A limitation across key questions was heterogeneity in outcomes, populations and study designs; this level of diversity in the knowledge base precluded us from pooling results statistically.

Specific limitations of the literature for studies addressing KQ 1 (i.e., the effects of health literacy and/or numeracy on health outcomes) included the following:

- An inconsistent approach to creating health literacy and numeracy levels or thresholds—i.e., cutpoints—in analyses, making comparisons between studies difficult.
- Lack of an analytic framework or logic model for determining the appropriate set of potential confounding variables that need to be included in multivariate models. While studies generally controlled for some socio-demographic variables and other factors, the choice of variables varies across studies. Also, many studies controlled for educational attainment and did not evaluate whether it has a mediating effect on the relationship between health literacy and health outcomes.
- Small sample sizes, making it impossible for us to determine whether null findings represented a true lack of effect or simply reflected limitations in statistical power.
- Studies conducted in just one clinic or in other narrowly defined patient populations, rendering the applicability of findings to other settings or populations unknown. Only two studies were conducted within nationally representative samples: the National Assessment of Adult Literacy conducted in 2003 and the earlier National Adult Literacy Survey in 1992.
- Health literacy tools that continue to focus primarily on reading ability. Despite the Institute of Medicine's call for skills-based health literacy tools[29] (i.e., tools focused on a combination of oral or verbal, navigational, computer, or other skills necessary for individuals to manage their health), at the time of this update review none had been used in the literature we were able to review. Thus, we could not determine the relationship between use of these more sophisticated tools and health outcomes. We did, however, find evidence that development of tools that can measure these additional skills has begun.[185]
- A limited number of studies examining potential mediators of health literacy, such as self-efficacy, knowledge, or beliefs.
- Few studies examining the role of health literacy on health disparities. Most research focused on whether health literacy mediated the relationship between black race and health outcomes. We did not uncover research examining whether health literacy mediated the relationship between other races or ethnicity groups and health outcomes; neither did we find work that focused on individuals in different age or sex groups.

The limitations of the literature for studies addressing KQ 2 (i.e., the effects of interventions to mitigate low health literacy) included the following

- Lack of an adequate control or comparator group in many studies, limiting the ability to determine the true effect(s) of the intervention.

- Measurement of multiple outcomes with insufficient attention to ensure that each is adequately powered to detect a difference.
- Testing interventions that combined various design features to mitigate the effect of low health literacy but offering no way to determine the effectiveness of individual components.
- Failure to perform adequately controlled subgroup analyses that would elucidate differential effects of interventions in low- and high-health literacy populations. This is important to the extent that the field's overall goal is to reduce disparities related to the impact of low health literacy rather than simply to improve outcomes for individuals at all health literacy levels.
- Failure to report adequately the design features that would allow future content analyses of effective interventions.

Limitations of Our Review

In addition to clarifying the limitations of the overall body of literature, we must also acknowledge the limitations of our systematic review and update of the 2004 report. First, we included only those studies in which investigators quantitatively measured the literacy of their populations. We may have missed some important studies addressing the relationship of health literacy on health outcomes or important interventions that either did not measure health literacy or measured it only by self-report. Second, we excluded studies that included only outcomes focused on communication or decisionmaking. Our reason for this was that, in our judgment, patient-physician communication likely moderated rather than mediated the effect of intent for behavior on health outcomes. Again, this may have meant we missed potentially important relationships or promising interventions. Third, we did not conduct dual *independent* abstraction of all information for review. Rather, a single reviewer abstracted information and a second reviewer checked it; we feel this process was sufficiently rigorous to allow accurate conclusions and it is the basic strategy the RTI-UNC EPC has used for this step for more than a decade. We did, however, perform dual review for article inclusion and dual rating of the risk of bias of individual studies and the strength of evidence in relation to outcomes, highlighting an overall rigorous process. Fourth, we did not formally integrate the analyses from our 2004 and current reviews, although based on our review of summary materials, we suspect this would have a minimum impact on our overall conclusions.

Future Research

This update shows that the field of health literacy has advanced since our 2004 review. However, many opportunities remain for important future research. The need for such investigations is considerable for gaining a better understanding of the outcomes of health care, given levels of health literacy, and for expanding the knowledge base about the impact of interventions intended to improve health literacy.

Future Research into the Relationship Between Health Literacy and Health Outcomes

Instrument cutpoints. The field will greatly benefit from additional investigation into the most relevant cutpoints for distinguishing levels of health literacy. Currently, investigators use cutpoints inconsistently, such that "adequate" and "inadequate" or "low" health literacy levels have different definitions across studies. This problem makes comparing results from these studies difficult. Additionally, the literature as a whole does not lend itself to explaining at what particular level lower health literacy is related to significantly poorer outcomes of health care.

Furthermore, sometimes a middle group, often referred to as "marginal health literacy," is identified; other times, no such group is specified. Sometimes research teams combine the middle health literacy group with the higher health literacy group; sometimes they do this combination with the lower health literacy group.

In short, those conducting work in this area in future should establish what is considered an inadequate, a marginal, and an adequate level of health literacy across instruments. In addition, they should consistently define cutpoints across studies.

Skills-based measures. Testing skills-based health literacy measures will be an important focus of future research. Our current review expanded the tools that measure health literacy to include those that focus on numeracy, but new instruments are likely to be available in the near future that can be used as alternative measures of health literacy that capture additional and potentially critical skills. For example, the Institute of Medicine 2009 workshop and resulting report *Measures of Health Literacy,* highlights that several skills-based measurement tools are under development—one designed for use in clinics and a second for population-based surveillance.[186] Future research should consider these and other measures that may explain the interplay of a wider range of health literacy skills and outcomes.

Consistent with the points above, before introducing new instruments researchers should consider appropriate cutpoints for measuring level of health literacy. Thus, they can try to ensure that new instruments do not exacerbate the concerns about unhelpful diversity in cutpoints and categories of health literacy.

Future research should also consider whether new tools capture changing competencies over time based on greater knowledge or experience (or both), resulting in scores changing over time. With this type of tool, prospective research designs will be critical, allowing researchers to measure health literacy at different times while in treatment or after different amounts of experience managing a chronic condition.

Links between low literacy and outcomes. Additional work is needed to help us understand the pathways by which low health literacy affects outcomes. A few studies examined variables that may be in the analytic pathway between health literacy and health outcomes and mediate the relationship between the two – including knowledge, self-efficacy and beliefs. More research is needed investigating these potential mediators in relation to a wider range of outcomes and populations. Other potential variables that warrant serious attention as mediators or moderators of the relationship include measures of education, social support, cultural competency, decision making skills, and trust in the information source.

Population subgroups. Additional research is needed to understand whether health literacy has a differential effect in various subgroups of the population. For example, we lack data evaluating whether the effect of low health literacy would be significantly different in different groups defined by various sociodemographic factors. Of particular interest are the following

comparisons: white populations versus various racial and/or ethnic minority populations; nonelderly versus elderly individuals; and male versus female patients.

Methodologic limitations. Current work should continue to address the basic methodological deficiencies we found during this update and were problems we noted in the previous review. For instance, researchers need to determine a minimal set of confounding variables that need to be considered for all multivariate analyses and sample sizes need to be larger so that investigators truly have sufficient power to detect differences among the three health literacy levels.

Applicability of research. The degree to which results from the studies done to date can be applied broadly is limited. Considering the "PICOTS" framework (patients/populations, interventions, comparators, outcomes, timeframes, and settings) for considering the generalizability of a body of research, we conclude that the ability of decisionmakers to generalize results from the current body of work is not great. Most current studies were limited to one clinic or one geographic area; thus, we lack evidence that the results would apply in more broadly defined populations or settings. The field needs to examine the relationships between health literacy and health outcomes in more diverse and representative populations.

Future Research into Interventions to Mitigate the Effects of Low Health Literacy

Opportunities to study interventions to mitigate the effects of low health literacy are also substantial.

Effective design of health-related documents. Additional work is needed on the design features of documents. As discussed just below, we identified several promising design features of health-related interventions that could mitigate the effects of low health literacy. The majority have been examined in only one study and, thus, they warrant further investigation.

An important question to answer is, "What needs study and what does not?" Our review failed to turn up evidence regarding several document design features widely recommended by experts in the field of health literacy; these include grouping or "chunking" of ideas and teach back.[187] However, whether these features require specific investigation in relation to health literacy when they have been well studied in other fields is not clear. For instance, the field of psycholinguistics has done extensive testing of simplified sentence and document structure and the cohesiveness of concepts in the text; this body of work, albeit not necessarily stemming from the health sector, may obviate the need for specific testing of these approaches in the health literacy field per se.[188] Furthermore, the educational literature has tested techniques of explicit instruction that are recommended for poor readers —i.e., instruction that has a clear task and is broken into small steps with practice and feedback at every step— and determined that they are effective.[188] Rather than spending time and energy on additional testing, exploring the extent to which other fields can inform the work of health literacy may be more appropriate.

Some design features, however, may warrant explicit testing. Given the evidence from multiple areas of study that motivation increases the effects of comprehension and behavior,[62,188,189] more study of the impact of illustrations, videos, photonovellas, and other novel approaches that may increase motivation for information processing through their visual appeal seems warranted.

Further testing of techniques based on oral and numerical delivery of information will also be useful. Oral information receives different cognitive processing than written information and has

a naturally simpler syntax that may help low literacy individuals.[188] Numbers and graphical numerical information have many alternative forms of presentation. These have been shown to affect understanding in high literacy individuals; they should be tested for comprehension among those with lower literacy.[190-195]

Finally, investigation of "work around" interventions should be undertaken. These can include use of patient advocates, who could accompany individuals to medical appointments and facilitate subsequent care.

Effective components of combination interventions. Additional work is also needed to determine the effective components of already tested interventions that have employed a combination of features to mitigate the effects of low health literacy. Several possibilities for accomplishing this task exist. For instance, one approach is to conduct a qualitative content analysis of existing interventions. Another approach is to conduct a meta-regression of the results of existing studies; in such analyses, investigators enter data about the features of interventions into a statistical program to determine their relative impact on relevant outcomes. Finally, additional trials could be run to test components of effective interventions.

Conclusions

Our systematic review update confirms that lower health literacy as measured by poorer reading skills is associated with a range of adverse health outcomes. Evidence is beginning to emerge concerning the relationship between poorer numeracy skills and health outcomes but the evidence is still too weak to be confident of an association. We found no evidence evaluating oral (verbal) health literacy and health outcomes.

Rigorous, well-designed studies of interventions to mitigate the effects of low health literacy have been conducted since our earlier review. Future studies isolating one measurable and replicable component of an intervention will, however, be particularly helpful in building this body of evidence. Many studies have now been conducted with a variety of clinic populations. Future research could enhance our confidence in the more universal applicability of results by including more broadly based and representative samples.

References

1. Berkman ND, Dewalt DA, Pignone MP, et al. Literacy and health outcomes. Evid Rep Technol Assess (Summ). 2004 Jan(87):1-8.

2. Ratzan SC, Parker RM. National library of medicine current bibliographies in medicine: health literacy. In: Selden CR, Zorn M, Ratzan SC, et al., eds. Bethesda, M: National Institutes of Health, U.S.Department of Health and Human Services 2000.

3. US Department of Health and Human Services. 11: Health Communication, *in* Healthy People 2010: Objectives for Improving Health 2000 [cited 2008 July 19]; 2nd edition:[Available from: http://www.healthypeople.gov/Document/pdf/uih/2010uih.pdf

4. Institute of Medicine. Health literacy: a prescription to end confusion - executive summary. 2004 [cited 2008 November 26]; Available from: http://www.nap.edu/catalog/10883.html

5. American Medical Association. Health literacy: report of the Council on Scientific Affairs. J Am Med Assoc. 1999;281(6):552-7.

6. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. Health Promot Intl. 2000;15:259-67.

7. Berkman ND, Davis TC, McCormack LA. Health literacy: what is it? Journal of Health Communications. in press.

8. Rothman RL, Housam R, Weiss H, et al. Patient understanding of food labels: the role of literacy and numeracy. Am J Prev Med. 2006 Nov;31(5):391-8.

9. Kirsch IS, Jungeblut A, Jenkins L, et al. Adult literacy in America: a first look at the findings of the National Adult Literacy Survey. 2002 [cited 2008 July 19]; 3rd edition:[Available from: http://nces.ed.gov/pubs93/93275.pdf

10. Kutner M, Greenberg E, Jin Y, et al. The health literacy of America's adults: results from the 2003 National Assessment of Adult Literacy. 2006 [cited 2008 November 17]; Available from: http://eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/29/e0/00.pdf

11. Rudd RE. Health literacy skills of U.S. adults. Am J Health Behav. 2007 Sep-Oct;31 Suppl 1:S8-18.

12. Rothman RL, Montori VM, Cherrington A, et al. Perspective: the role of numeracy in health care. J Health Commun. 2008 Sep;13(6):583-95.

13. Baker DW, Gazmararian JA, Sudano J, et al. The association between age and health literacy among elderly persons. J Gerontol B Psychol Sci Soc Sci. 2000 November 1, 2000;55(6):S368-74.

14. Davis T, Crouch M, Wills G, et al. The gap between patient reading comprehension and the readability of patient education materials. J Fam Pract. 1990;31:533-8.

15. Nath CR, Sylvester ST, Yasek V, et al. Development and validation of a literacy assessment tool for persons with diabetes The Diabetes Educator. 2001;27(6):857-64.

16. Lee JY, Rozier RG, Lee SY, et al. Development of a word recognition instrument to test health literacy in dentistry: the REALD-30--a brief communication. J Public Health Dent. 2007 Spring;67(2):94-8.

17. Davis T, Long S, Jackson R, et al. Rapid estimate of adult literacy in medicine: a shortened screening instrument. Fam Med. 1993 June;25(6):391-5.

18. Parker R, Baker D, Williams M, et al. The test of functional health literacy in adults. J Gen Intern Med. 1995;10(10):537-41.

19. Wilkinson G. Wide Range Achievement Test 3 - Administration Manual. Wilmington, DE: Jastak Associates, Inc. 1993.

20. Woodcock RW, Mather N. WJ-R tests of achievement: examiner's manual; 1989, 1990.

21. Rothman RL, Malone R, Bryant B, et al. The Spoken Knowledge in Low Literacy in Diabetes scale: a diabetes knowledge scale for vulnerable patients. Diabetes Educ. 2005 Mar-Apr;31(2):215-24.

22. Lipkus IM, Samsa G, Rimer BK. General performance on a numeracy scale among highly educated samples. Med Decis Making. 2001 Jan-Feb;21(1):37-44.

23. Schwartz LM, Woloshin S, Black WC, et al. The role of numeracy in understanding the benefit of screening mammography. Ann Intern Med. 1997 Dec 1;127(11):966-72.

24. Jastak S, Wilkinson G. Wide Range Achievement Test-Revised (WRAT-R). San Antonio, TX: The Psychological Corporation 1984.

25. Baker DW, Williams MV, Parker RM, et al. Development of a brief test to measure functional health literacy. Patient Educ Couns. 1999 Sep;38(1):33-42.

26. Berkman ND, DeWalt DA, Pignone MP, et al. Summary, Evidence Report/Technology Assessment No. 87. 2004 [cited 2008 July 19]; Available from: http://www.ahrq.gov/clinic/epcsums/litsum.pdf

27. Dewalt DA, Berkman ND, Sheridan S, et al. Literacy and health outcomes: a systematic review of the literature. J Gen Intern Med. 2004 Dec;19(12):1228-39.

28. Pignone M, DeWalt DA, Sheridan S, et al. Interventions to improve health outcomes for patients with low literacy. A systematic review. J Gen Intern Med. 2005 Feb;20(2):185-92.

29. Institute of Medicine. Report Brief - Health Literacy: A Prescription To End Confusion. 2004 [cited 2008 July 19]; Available from: http://www.iom.edu/Object.File/Master/19/726/health%20literacy%20final.pdf

30. Fishbein M. The role of theory in HIV prevention. AIDS Care. 2000 Jun;12(3):273-8.

31. Paasche-Orlow MK, Wolf MS. The causal pathways linking health literacy to health outcomes. Am J Health Behav. 2007 Sep-Oct;31 Suppl 1:S19-26.

32. Berkman ND, Viswanathan M. Development of a tool to evaluate the quality of observational studies. (Abstract). Zeitschrift für Evidenz, Fortbildung, und Qualität im Gesundheitswesen (German Journal for Evidence and Quality in Health Care). 2008;102(Supple V):S.19.

33. Owens DK, Lohr KN, Atkins D, 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 May;63(5):513-23.

34. Gazmararian JA, Kripalani S, Miller MJ, et al. Factors associated with medication refill adherence in cardiovascular-related diseases: a focus on health literacy. J Gen Intern Med. 2006 Dec;21(12):1215-21.

35. Baker DW, Gazmararian JA, Williams MV, et al. Health literacy and use of outpatient physician services by Medicare managed care enrollees. J Gen Intern Med. 2004 Mar;19(3):215-20.

36. 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 Aug;21(8):857-61.

37. Wolf MS, Gazmararian JA, Baker DW. Health literacy and health risk behaviors among older adults. Am J Prev Med. 2007 Jan;32(1):19-24.

38. Baker DW, Wolf MS, Feinglass J, et al. Health literacy and mortality among elderly persons. Arch Intern Med. 2007 Jul 23;167(14):1503-9.

39. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. Arch Intern Med. 2005 Sep 26;165(17):1946-52.

40. Baker DW, Wolf MS, Feinglass J, et al. Health literacy, cognitive abilities, and mortality among elderly persons. J Gen Intern Med. 2008 Jun;23(6):723-6.

41. 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 Apr;118(4):371-7.

42. Osborn CY, Paasche-Orlow MK, Davis TC, et al. Health literacy: an overlooked factor in understanding HIV health disparities. Am J Prev Med. 2007 Nov;33(5):374-8.

43. Wolf MS, Davis TC, Osborn CY, et al. Literacy, self-efficacy, and HIV medication adherence. Patient Educ Couns. 2007 Feb;65(2):253-60.

44. Waite KR, Paasche-Orlow M, Rintamaki LS, et al. Literacy, social stigma, and HIV medication adherence. J Gen Intern Med. 2008 Sep;23(9):1367-72.

45. Davis TC, Wolf MS, Bass PF, 3rd, et al. Literacy and misunderstanding prescription drug labels. Ann Intern Med. 2006 Dec 19;145(12):887-94.

46. Wolf MS, Davis TC, Shrank W, et al. To err is human: patient misinterpretations of prescription

drug label instructions. Patient Educ Couns. 2007 Aug;67(3):293-300.

47. Baker D, Wolf M, Feinglass J, et al. Health literacy, cognitive abilities, and mortality among elderly persons. J Gen Intern Med. 2008;23(6):723-6.

48. Barragan M, Hicks G, Williams MV, et al. Low health literacy is associated with HIV test acceptance. J Gen Intern Med. 2005 May;20(5):422-5.

49. Bennett IM, Culhane JF, McCollum KF, et al. Literacy and depressive symptomatology among pregnant Latinas with limited English proficiency. Am J Orthopsychiatry. 2007 Apr;77(2):243-8.

50. Bennett IM, Chen J, Soroui JS, et al. The contribution of health literacy to disparities in self-rated health status and preventive health behaviors in older adults. Ann Fam Med. 2009 May-Jun;7(3):204-11.

51. Chew LD, Bradley KA, Flum DR, et al. The impact of low health literacy on surgical practice. Am J Surg. 2004 Sep;188(3):250-3.

52. Cho YI, Lee SY, Arozullah AM, et al. Effects of health literacy on health status and health service utilization amongst the elderly. Soc Sci Med. 2008 Apr;66(8):1809-16.

53. DeWalt DA, Dilling MH, Rosenthal MS, et al. Low parental literacy is associated with worse asthma care measures in children. Ambul Pediatr. 2007 Jan-Feb;7(1):25-31.

54. Estrada CA, Martin-Hryniewicz M, Peek BT, et al. Literacy and numeracy skills and anticoagulation control. Am J Med Sci. 2004 Aug;328(2):88-93.

55. Fang MC, Machtinger EL, Wang F, et al. Health literacy and anticoagulation-related outcomes among patients taking warfarin. J Gen Intern Med. 2006 Aug;21(8):841-6.

56. 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 Oct;1(4):A07.

57. Graham J, Bennett IM, Holmes WC, et al. Medication beliefs as mediators of the health literacy-antiretroviral adherence relationship in HIV-infected individuals. AIDS Behav. 2007 May;11(3):385-92.

58. Grubbs V, Gregorich SE, Perez-Stable EJ, et al. Health literacy and access to kidney transplantation. Clin J Am Soc Nephrol. 2009 Jan;4(1):195-200.

59. Guerra CE, Dominguez F, Shea JA. Literacy and knowledge, attitudes, and behavior about colorectal cancer screening. J Health Commun. 2005 Oct-Nov;10(7):651-63.

60. Guerra CE, Krumholz M, Shea JA. Literacy and knowledge, attitudes and behavior about mammography in Latinas. J Health Care Poor Underserved. 2005 Feb;16(1):152-66.

61. Hahn EA, Cella D, Dobrez DG, et al. The impact of literacy on health-related quality of life measurement and outcomes in cancer outpatients. Qual Life Res. 2007 Apr;16(3):495-507.

62. Hibbard JH, Peters E, Dixon A, et al. Consumer competencies and the use of comparative quality information: it isn't just about literacy. Med Care Res Rev. 2007 Aug;64(4):379-94.

63. Hironaka LK, Paasche-Orlow MK, Young RL, et al. Caregiver health literacy and adherence to a daily multi-vitamin with iron regimen in infants. Patient Educ Couns. 2009 Jun;75(3):376-80.

64. Hope CJ, Wu J, Tu W, et al. 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 Oct 1;61(19):2043-9.

65. Huizinga MM, Beech BM, Cavanaugh KL, et al. Low numeracy skills are associated with higher BMI. Obesity (Silver Spring). 2008 Aug;16(8):1966-8.

66. Johnson JD, Case DO, Andrews JE, et al. Genomics--the perfect information-seeking research problem. J Health Commun. 2005 Jun;10(4):323-9.

67. Kalichman SC, Pope H, White D, et al. Association between health literacy and HIV treatment adherence: further evidence from objectively measured medication adherence. J Int Assoc Physicians AIDS Care (Chic Ill). 2008 Nov-Dec;7(6):317-23.

68. Kripalani S, Henderson LE, Chiu EY, et al. Predictors of medication self-management skill in a low-literacy population. J Gen Intern Med. 2006 Aug;21(8):852-6.

69. Laramee AS, Morris N, Littenberg B. Relationship of literacy and heart failure in adults with diabetes. BMC Health Serv Res. 2007;7:98.

70. Lee S-YD, Arozullah AM, Cho YI, et al. Health literacy, social support, and health status among older adults. Educational Gerontology. 2009 03;35(3):191-201.

71. LeVine RA, LeVine SE, Rowe ML, et al. Maternal literacy and health behavior: a Nepalese case study. Soc Sci Med. 2004 Feb;58(4):863-77.

72. Lincoln A, Paasche-Orlow MK, Cheng DM, 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 Aug;21(8):818-22.

73. 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 Aug;21(8):829-34.

74. Mancuso CA, Rincon M. Impact of health literacy on longitudinal asthma outcomes. J Gen Intern Med. 2006 Aug;21(8):813-7.

75. Mancuso CA, Rincon M. Asthma patients' assessments of health care and medical decision making: the role of health literacy. J Asthma. 2006 Jan-Feb;43(1):41-4.

76. Marteleto L, Lam D, Ranchhod V. Sexual behavior, pregnancy, and schooling among young people in urban South Africa. Stud Fam Plann. 2008 Dec;39(4):351-68.

77. Mayben JK, Kramer JR, Kallen MA, et al. Predictors of delayed HIV diagnosis in a recently diagnosed cohort. Aids Patient Care STDS. 2007 Mar;21(3):195-204.

78. Miller DP, Jr., Brownlee CD, McCoy TP, et al. The effect of health literacy on knowledge and receipt of colorectal cancer screening: a survey study. BMC Fam Pract. 2007;8:16.

79. 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.

80. Muir KW, Santiago-Turla C, Stinnett SS, et al. Health literacy and vision-related quality of life. Br J Ophthalmol. 2008 Jun;92(6):779-82.

81. Murray MD, Tu W, Wu J, et al. Factors associated with exacerbation of heart failure include treatment adherence and health literacy skills. Clin Pharmacol Ther. 2009 Jun;85(6):651-8.

82. Nokes KM, Coleman CL, Cashen M, et al. Health literacy and health outcomes in HIV seropositive persons. Res Nurs Health. 2007 Dec;30(6):620-7.

83. Paasche-Orlow MK, Riekert KA, Bilderback A, et al. Tailored education may reduce health literacy disparities in asthma self-management. Am J Respir Crit Care Med. 2005 Oct 15;172(8):980-6.

84. Paasche-Orlow MK, Clarke JG, Hebert MR, et al. Educational attainment but not literacy is associated with HIV risk behavior among incarcerated women. J Womens Health (Larchmt). 2005 Nov;14(9):852-9.

85. Paasche-Orlow MK, Cheng DM, Palepu A, et al. Health literacy, antiretroviral adherence, and HIV-RNA suppression: a longitudinal perspective. J Gen Intern Med. 2006 Aug;21(8):835-40.

86. Pandit AU, Tang JW, Bailey SC, et al. Education, literacy, and health: Mediating effects on hypertension knowledge and control. Patient Educ Couns. 2009 Jun;75(3):381-5.

87. Peterson NB, Dwyer KA, Mulvaney SA, et al. The influence of health literacy on colorectal cancer screening knowledge, beliefs and behavior. J Natl Med Assoc. 2007 Oct;99(10):1105-12.

88. Powell M. Perspectives in ambulatory care Health literacy: implications for ambulatory care. Nursing Economic$. 2009;27(5):343-7.

89. Powers BJ, Olsen MK, Oddone EZ, et al. Literacy and blood pressure--do healthcare systems influence this relationship? A cross-sectional study. BMC Health Serv Res. 2008;8:219.

90. Raehl CL, Bond CA, Woods TJ, et al. Screening tests for intended medication adherence among the elderly. Ann Pharmacother. 2006 May;40(5):888-93.

91. Schillinger D, Barton LR, Karter AJ, et al. Does literacy mediate the relationship between education and health outcomes? A study of a low-income population with diabetes. Public Health Rep. 2006 May-Jun;121(3):245-54.

92. Sentell TL, Halpin HA. Importance of adult literacy in understanding health disparities. J Gen Intern Med. 2006 Aug;21(8):862-6.

93. Shone LP, Conn KM, Sanders L, et al. The role of parent health literacy among urban children with persistent asthma. Patient Educ Couns. 2009 Jun;75(3):368-75.

94. Smith JL, Haggerty J. Literacy in primary care populations: is it a problem? Can J Public Health. 2003 Nov-Dec;94(6):408-12.

95. Sudore RL, Yaffe K, Satterfield S, et al. Limited literacy and mortality in the elderly: the health, aging, and body composition study. J Gen Intern Med. 2006 Aug;21(8):806-12.

96. Sudore RL, Mehta KM, Simonsick EM, et al. Limited literacy in older people and disparities in health and healthcare access. J Am Geriatr Soc. 2006 May;54(5):770-6.

97. Tang YH, Pang SM, Chan MF, et al. Health literacy, complication awareness, and diabetic control in patients with type 2 diabetes mellitus. J Adv Nurs. 2008 Apr;62(1):74-83.

98. Torres RY, Marks R. Relationships among health literacy, knowledge about hormone therapy, self-efficacy, and decision-making among postmenopausal health. J Health Commun. 2009 Jan-Feb;14(1):43-55.

99. von Wagner C, Knight K, Steptoe A, et al. Functional health literacy and health-promoting behaviour in a national sample of British adults. J Epidemiol Community Health. 2007 Dec;61(12):1086-90.

100. von Wagner C, Semmler C, Good A, et al. Health literacy and self-efficacy for participating in colorectal cancer screening: The role of information processing. Patient Educ Couns. 2009 Jun;75(3):352-7.

101. Walker D, Adebajo A, Heslop P, et al. Patient education in rheumatoid arthritis: the effectiveness of the ARC booklet and the mind map. Rheumatology (Oxford). 2007 Oct;46(10):1593-6.

102. 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 Jan-Feb;17(1):44-7.

103. White S, Chen J, Atchison R. Relationship of preventive health practices and health literacy: a national study. Am J Health Behav. 2008 May-Jun;32(3):227-42.

104. Wolf MS, Knight SJ, Lyons EA, et al. Literacy, race, and PSA level among low-income men newly diagnosed with prostate cancer. Urology. 2006 Jul;68(1):89-93.

105. Wolf MS, Davis TC, Shrank WH, et al. A critical review of FDA-approved Medication Guides. Patient Educ Couns. 2006 Sep;62(3):316-22.

106. Yin HS, Dreyer BP, Foltin G, et 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 Jul-Aug;7(4):292-8.

107. Powell CK, Hill EG, Clancy DE. The relationship between health literacy and diabetes knowledge and readiness to take health actions. Diabetes Educ. 2007 Jan-Feb;33(1):144-51.

108. Johnston MV, Diab ME, Kim SS, et al. Health literacy, morbidity, and quality of life among individuals with spinal cord injury. J Spinal Cord Med. 2005;28(3):230-40.

109. Scott TL, Gazmararian JA, Williams MV, et al. Health Literacy and Preventive Health Care Use Among Medicare Enrollees in a Managed Care Organization. Med Care. 2002 May;40(5):395-404.

110. Fortenberry JD, McFarlane MM, Hennessy M, et al. Relation of health literacy to gonorrhoea related care. Sex Transm Infect. 2001 Jun;77(3):206-11.

111. Baker DW, Parker RM, Williams MV, et al. The relationship of patient reading ability to self-reported health and use of health services. Am J Public Health. 1997 June 1, 1997;87(6):1027-30.

112. Frack SA, Woodruff SI, Candelaria J, et al. Correlates of compliance with measurement protocols in a Latino nutrition-intervention study. Am J Prev Med. 1997 Mar-Apr;13(2):131-6.

113. Golin CE, Liu H, Hays RD, et al. A prospective study of predictors of adherence to combination antiretroviral medication. J Gen Intern Med. 2002 Oct;17(10):756-65.

114. Kalichman SC, Ramachandran B, Catz S. Adherence to combination antiretroviral therapies in HIV patients of low health literacy. J Gen Intern Med. 1999 May;14(5):267-73.

115. Li BD, Brown WA, Ampil FL, et al. Patient compliance is critical for equivalent clinical outcomes for breast cancer treated by breast-

conservation therapy. Ann Surg. 2000 Jun;231(6):883-9.

116. Sheridan SL, Pignone M. Numeracy and the medical student's ability to interpret data. Eff Clin Pract. 2002 Jan-Feb;5(1):35-40.

117. Sheridan SL, Pignone MP, Lewis CL. A randomized comparison of patients' understanding of number needed to treat and other common risk reduction formats. J Gen Intern Med. 2003 Nov;18(11):884-92.

118. Cavanaugh K, Huizinga MM, Wallston KA, et al. Association of numeracy and diabetes control. Ann Intern Med. 2008 May 20;148(10):737-46.

119. Davids SL, Schapira MM, McAuliffe TL, et al. Predictors of pessimistic breast cancer risk perceptions in a primary care population. J Gen Intern Med. 2004 Apr;19(4):310-5.

120. Haggstrom DA, Schapira MM. Black-white differences in risk perceptions of breast cancer survival and screening mammography benefit. J Gen Intern Med. 2006 Apr;21(4):371-7.

121. Vavrus F. Girls' schooling in Tanzania: the key to HIV/AIDS prevention? AIDS Care. 2006 Nov;18(8):863-71.

122. Aggarwal A, Speckman JL, Paasche-Orlow MK, et al. The role of numeracy on cancer screening among urban women. Am J Health Behav. 2007 Sep-Oct;31 Suppl 1:S57-68.

123. Peters E, Hibbard J, Slovic P, et al. Numeracy skill and the communication, comprehension, and use of risk-benefit information. Health Aff (Millwood). 2007 May-Jun;26(3):741-8.

124. Seligman HK, Wang FF, Palacios JL, et al. Physician notification of their diabetes patients' limited health literacy. A randomized, controlled trial. J Gen Intern Med. 2005 Nov;20(11):1001-7.

125. Murray MD, Young J, Hoke S, et al. Pharmacist intervention to improve medication adherence in heart failure: a randomized trial. Ann Intern Med. 2007 May 15;146(10):714-25.

126. Rothman RL, DeWalt DA, Malone R, et al. Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. JAMA. 2004 Oct 13;292(14):1711-6.

127. Greene J, Peters E, Mertz CK, et al. Comprehension and choice of a consumer-directed health plan: an experimental study. Am J Manag Care. 2008 Jun;14(6):369-76.

128. Wright AJ, Whitwell SC, Takeichi C, et al. The impact of numeracy on reactions to different graphic risk presentation formats: An experimental analogue study. Br J Health Psychol. 2009 Feb;14(Pt 1):107-25.

129. Schillinger D, Hammer H, Wang F, et al. Seeing in 3-D: examining the reach of diabetes self-management support strategies in a public health care system. Health Educ Behav. 2008 Oct;35(5):664-82.

130. Peters E, Dieckmann N, Dixon A, et al. Less is more in presenting quality information to consumers. Med Care Res Rev. 2007 Apr;64(2):169-90.

131. Mayhorn CB, Goldsworthy RC. Refining teratogen warning symbols for diverse populations. Birth Defects Res A Clin Mol Teratol. 2007 Jun;79(6):494-506.

132. Kripalani S, Robertson R, Love-Ghaffari MH, et al. Development of an illustrated medication schedule as a low-literacy patient education tool. Patient Educ Couns. 2007 Jun;66(3):368-77.

133. Yates K, Pena A. Comprehension of discharge information for minor head injury: a randomised controlled trial in New Zealand. N Z Med J. 2006;119(1239):U2101.

134. Sudore RL, Landefeld CS, Williams BA, et al. Use of a modified informed consent process among vulnerable patients: a descriptive study. J Gen Intern Med. 2006 Aug;21(8):867-73.

135. Weiss BD, Francis L, Senf JH, et al. Literacy education as treatment for depression in patients with limited literacy and depression: a randomized controlled trial. J Gen Intern Med. 2006 Aug;21(8):823-8.

136. Gerber BS, Brodsky IG, Lawless KA, et al. Implementation and evaluation of a low-literacy diabetes education computer multimedia application. Diabetes Care. 2005 Jul;28(7):1574-80.

137. Hwang SW, Tram CQ, Knarr N. The effect of illustrations on patient comprehension of medication instruction labels. BMC Fam Pract. 2005 Jun 16;6(1):26.

138. Ferreira MR, Dolan NC, Fitzgibbon ML, et al. Health care provider-directed intervention to increase colorectal cancer screening among

veterans: results of a randomized controlled trial. J Clin Oncol. 2005 Mar 1;23(7):1548-54.

139. Kim S, Love F, Quistberg DA, et al. Association of health literacy with self-management behavior in patients with diabetes. Diabetes Care. 2004 Dec;27(12):2980-2.

140. Rothman R, Malone R, Bryant B, et al. The relationship between literacy and glycemic control in a diabetes disease-management program. Diabetes Educ. 2004 Mar-Apr;30(2):263-73.

141. Coyne CA, Xu R, Raich P, et al. Randomized, controlled trial of an easy-to-read informed consent statement for clinical trial participation: a study of the Eastern Cooperative Oncology Group. J Clin Oncol. 2003 Mar 1;21(5):836-42.

142. Campbell FA, Goldman BD, Boccia ML, et al. The effect of format modifications and reading comprehension on recall of informed consent information by low-income parents: a comparison of print, video, and computer-based presentations. Patient Educ Couns. 2004 May;53(2):205-16.

143. Bosworth HB, Olsen MK, Gentry P, et al. Nurse administered telephone intervention for blood pressure control: a patient-tailored multifactorial intervention. Patient Educ Couns. 2005 Apr;57(1):5-14.

144. DeWalt DA, Malone RM, Bryant ME, et al. A heart failure self-management program for patients of all literacy levels: a randomized, controlled trial [ISRCTN11535170]. BMC Health Serv Res. 2006;6:30.

145. Kripalani S, Sharma J, Justice E, et al. Low-literacy interventions to promote discussion of prostate cancer: a randomized controlled trial. Am J Prev Med. 2007 Aug;33(2):83-90.

146. Sudore RL, Landefeld CS, Barnes DE, et al. An advance directive redesigned to meet the literacy level of most adults: a randomized trial. Patient Educ Couns. 2007 Dec;69(1-3):165-95.

147. Davis TC, Wolf MS, Bass PF, et al. Provider and patient intervention to improve weight loss: a pilot study in a public hospital clinic. Patient Educ Couns. 2008 Jul;72(1):56-62.

148. Kripalani S, Bengtzen R, Henderson LE, et al. Clinical research in low-literacy populations: using teach-back to assess comprehension of informed consent and privacy information. IRB. 2008 Mar-Apr;30(2):13-9.

149. Robinson LD, Jr., Calmes DP, Bazargan M. The impact of literacy enhancement on asthma-related outcomes among underserved children. J Natl Med Assoc. 2008 Aug;100(8):892-6.

150. Sudore RL, Schickedanz AD, Landefeld CS, et al. Engagement in multiple steps of the advance care planning process: a descriptive study of diverse older adults. J Am Geriatr Soc. 2008 Jun;56(6):1006-13.

151. Rudd RE, Blanch DC, Gall V, et al. A randomized controlled trial of an intervention to reduce low literacy barriers in inflammatory arthritis management. Patient Educ Couns. 2009 Jun;75(3):334-9.

152. Schillinger D, Handley M, Wang F, et al. Effects of self-management support on structure, process, and outcomes among vulnerable patients with diabetes: a three-arm practical clinical trial. Diabetes Care. 2009 Apr;32(4):559-66.

153. Wallace AS, Seligman HK, Davis TC, et al. Literacy-appropriate educational materials and brief counseling improve diabetes self-management. Patient Educ Couns. 2009 Jun;75(3):328-33.

154. Brock TP, Smith SR. Using digital videos displayed on personal digital assistants (PDAs) to enhance patient education in clinical settings. Int J Med Inform. 2007 Nov-Dec;76(11-12):829-35.

155. Kalichman SC, Cherry J, Cain D. Nurse-delivered antiretroviral treatment adherence intervention for people with low literacy skills and living with HIV/AIDS. J Assoc Nurses AIDS Care. 2005 Sep-Oct;16(5):3-15.

156. van Servellen G, Nyamathi A, Carpio F, et al. Effects of a treatment adherence enhancement program on health literacy, patient-provider relationships, and adherence to HAART among low-income HIV-positive Spanish-speaking Latinos. Aids Patient Care STDS. 2005 Nov;19(11):745-59.

157. van Servellen G, Carpio F, Lopez M, et al. Program to enhance health literacy and treatment adherence in low-income HIV-infected Latino men and women. Aids Patient Care STDS. 2003 Nov;17(11):581-94.

158. DeWalt DA, Pignone M, Malone R, et al. Development and pilot testing of a disease management program for low literacy patients with heart failure. Patient Educ Couns. 2004 Oct;55(1):78-86.

159. Carbone ET, Lennon KM, Torres MI, et al. Testing the feasibility of an interactive learning styles measure for U.S. Latino Adults with type 2 diabetes and low literacy. International Quarterly of Community Health Education. 2006;25(4):315-35.

160. Kandula NR, Nsiah-Kumi PA, Makoul G, et al. The relationship between health literacy and knowledge improvement after a multimedia type 2 diabetes education program. Patient Educ Couns. 2009 Jun;75(3):321-7.

161. Bickmore TW, Pfeifer LM, Paasche-Orlow MK. Using computer agents to explain medical documents to patients with low health literacy. Patient Educ Couns. 2009 Jun;75(3):315-20.

162. Ntiri DW, Stewart M. Transformative learning intervention: effect on functional health literacy and diabetes knowledge in older African Americans. Gerontol Geriatr Educ. 2009;30(2):100-13.

163. Michielutte R, Bahnson J, Dignan MB, et al. The use of illustrations and narrative text style to improve readability of a health education brochure. J Cancer Educ. 1992;7(3):251-60.

164. Meade CD, McKinney WP, Barnas GP. Educating patients with limited literacy skills: the effectiveness of printed and videotaped materials about colon cancer. Am J Public Health. 1994 Jan;84(1):119-21.

165. Davis T, Fredrickson DD, Arnold C, et al. . A polio immunization pamphlet with increased appeal and simplified language does not improve comprehension to an acceptable level. Patient Educat Counsel. 1998;33(1):25-37.

166. Murphy PW, Chesson AL, Walker L, et al. Comparing the effectiveness of video and written material for improving knowledge among sleep disorders clinic patients with limited literacy skills. South Med J. 2000 Mar;93(3):297-304.

167. Davis TC, Berkel HJ, Arnold CL, et al. Intervention to increase mammography utilization in a public hospital. J Gen Intern Med. 1998 Apr;13(4):230-3.

168. Eaton ML, Holloway RL. Patient comprehension of written drug information. Am J Hosp Pharm. 1980 Feb;37(2):240-3.

169. Davis TC, Bocchini JA, Jr., Fredrickson D, et al. Parent comprehension of polio vaccine information pamphlets. Pediatrics. 1996 Jun;97(6 Pt 1):804-10.

170. Davis TC, Holcombe RF, Berkel HJ, et al. Informed consent for clinical trials: a comparative study of standard versus simplified forms. J Natl Cancer Inst. 1998 May 6;90(9):668-74.

171. Hayes KS. Randomized trial of geragogy-based medication instruction in the emergency department. Nurs Res. 1998 Jul-Aug;47(4):211-8.

172. Hussey LC. Minimizing effects of low literacy on medication knowledge and compliance among the elderly. Clin Nurs Res. 1994 May;3(2):132-45.

173. Kim SP, Knight SJ, Tomori C, et al. Health literacy and shared decision making for prostate cancer patients with low socioeconomic status. Cancer Invest. 2001;19(7):684-91.

174. Pepe M, Chodzko-Zajko WJ.. Impact of older adults' reading ability on the comprehension and recall of cholesterol information. J Health Educat. 1997;28(1):21-7.

175. Howard-Pitney B, Winkleby MA, Albright CL, et al. The Stanford Nutrition Action Program: a dietary fat intervention for low-literacy adults. Am J Public Health. 1997 Dec;87(12):1971-6.

176. Wydra EW. The effectiveness of a self-care management interactive multimedia module. Oncol Nurs Forum. 2001 Oct;28(9):1399-407.

177. Murphy PW, Davis TC, Mayeaux EJ, et al. Teaching nutrition education in adult learning centers: linking literacy, health care, and the community. J Community Health Nurs. 1996;13(3):149-58.

178. Raymond EG, Dalebout SM, Camp SI. Comprehension of a prototype over-the-counter label for an emergency contraceptive pill product. Obstet Gynecol. 2002 Aug;100(2):342-9.

179. Hartman TJ, McCarthy PR, Park RJ, et al. Results of a community-based low-literacy nutrition education program. J Community Health. 1997 Oct;22(5):325-41.

180. Kumanyika SK, Adams-Campbell L, Van Horn B, et al. Outcomes of a cardiovascular nutrition counseling program in African-Americans with elevated blood pressure or cholesterol level. J Am Diet Assoc. 1999 Nov;99(11):1380-91.

181. Dewalt DA, Davis TC, Wallace AS, et al. Goal setting in diabetes self-management: Taking the baby steps to success. Patient Educ Couns. 2009 Apr 7.

182. Davis TC, Fredrickson DD, Arnold C, et al. A polio immunization pamphlet with increased appeal and simplified language does not improve comprehension to an acceptable level. Patient Educ Couns. 1998 Jan;33(1):25-37.

183. Schroder FH, Hugosson J, Roobol MJ, et al. Screening and prostate-cancer mortality in a randomized European study. N Engl J Med. 2009 Mar 26;360(13):1320-8.

184. Andriole GL, Crawford ED, Grubb RL, 3rd, et al. Mortality results from a randomized prostate-cancer screening trial. N Engl J Med. 2009 Mar 26;360(13):1310-9.

185. Roter DL, Erby LH, Larson S, et al. Assessing oral literacy demand in genetic counseling dialogue: preliminary test of a conceptual framework. Soc Sci Med. 2007 Oct;65(7):1442-57.

186. Institute of Medicine. Measures of health litearcy, workshop summary 2009 [cited; Available from: http://books.nap.edu/openbook.php?record_id=12690

187. Doak CC, Leonard G. Doak, and Jane H. Root.. Teaching Patients With Low Literacy Skills 2d ed.: Philadelphia: Lippincott Co. 1996.

188. Snow CE. Reading for understanding: toward a research and development program in reading comprehension; 2002. Report No.: ISBN 0-8330-3105-8.

189. Petty RE, Barden, J., Wheeler, S.J. The Elaboration likelihood model of persuasion: Health Promtion that yield sustained behavior change. San Francisco: Jossey-Bass 2002.

190. Fagerlin A, Ubel PA, Smith DM, et al. Making numbers matter: present and future research in risk communication. Am J Health Behav. 2007 Sep-Oct;31 Suppl 1:S47-56.

191. Lipkus IM. Numeric, verbal, and visual formats of conveying health risks: suggested best practices and future recommendations. Med Decis Making. 2007 Sep-Oct;27(5):696-713.

192. McGettigan P, Sly K, O'Connell D, et al. The effects of information framing on the practices of physicians. J Gen Intern Med. 1999 Oct;14(10):633-42.

193. Edwards A, Elwyn G, Covey J, et al. Presenting risk information--a review of the effects of "framing" and other manipulations on patient outcomes. J Health Commun. 2001 Jan-Mar;6(1):61-82.

194. Moxey A, O'Connell D, McGettigan P, et al. Describing treatment effects to patients. J Gen Intern Med. 2003 Nov;18(11):948-59.

195. Covey J. A meta-analysis of the effects of presenting treatment benefits in different formats. Med Decis Making. 2007 Sep-Oct;27(5):638-54.