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Numeracy Skills, Health Information-Seeking, and Preventive Health Behaviors among Middle and Older Aged Adults in the U.S.

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Abstract

Background: Given the information/technology rich environment coupled with ongoing trends in population aging in the U.S., the central role that health literacy plays in determining health behaviors and outcomes has recently received an increasing amount of attention. Despite a growing research and policy focus on health literacy, some key components that constitute this multifaceted construct that reflects one's ability to access, process, and understand basic health information remain under-examined. Specifically, print and oral literacy have been extensively examined, but the potentially important role that numerical literacy (i.e., numeracy) plays in shaping health behaviors remains largely unknown. This issue is particularly pertinent for the older population, which is generally characterized by worsening overall physical and cognitive health. Therefore, we examined the role of numeracy in the context of relevant health determinants, including health information seeking and preventive health behaviors.

Methods: Data were obtained from the 2012/2014 Program for the International Assessment of Adult Competencies (PIAAC), which include a nationally representative sample of American adults ages 45-74 years old. Detailed descriptive statistics and appropriate regression analyses were conducted with the use of a SAS macro program developed by the International Association for the Evaluation of Educational Achievement (IEA). Multivariate associations between numeracy skills and eight health information sources (newspaper, magazines, internet, radio, television, books, friends and family, health professional) and four preventive health behaviors (flu shot, dental check-up, vision screening, osteoporosis screening) were estimated after adjusting for age, gender, race, educational attainment, employment status, self-rated health, literacy skills, and use of numeracy skills at home. The PIAAC final sampling weights and replicate weights were also used to generate nationally representative and unbiased findings.

Results: We provided detailed descriptive statistics for numeracy skills by demographic (i.e. age, gender, race) socioeconomic (i.e., education, and employment status) and health (i.e., self-rated health) characteristics, as well as by health information sources (i.e., health professionals, internet, television, friends and family, books, newspapers, magazines, and radio), and preventive health behaviors (i.e., flu shot, dental checkup, vision screening, and osteoporosis screening). Multivariate results, conditioned on these demographic, socioeconomic and health characteristics, and other controls, indicated that the medium to high numeracy proficiency was associated with less frequent use of magazines, books, television, and newspapers as health information sources with respect to the low numeracy proficiency. Furthermore, numeracy skills

were positively associated with dental checkups, but they were not associated with other preventive health practices, after accounting for the sociodemographic, health and other covariates.

Significance: The present study is among the first to provide a nationally representative overview and exploration of numeracy skills data among middle-aged and older adults in the U.S. Thus, results from the current study represent a foundation from which future research can build upon, which ideally will lead to the identification of specific pathways that link numeracy skills with health behaviors and outcomes. Findings highlight social and economic disparities in numeracy proficiency, and the potentially important role that numeracy skills play in determining health information seeking and preventive health behaviors. These findings are useful for informing policy discussions aimed at population health promotion. Specifically, it may be beneficial for future health education and communication to target specific health information sources and improve accessibility to the vulnerable populations who generally have lower numeracy skills.

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Background

The U.S. has been experiencing population aging. According to the 2010 Census, approximately one in eight Americans is 65-years-old or older, and this proportion is projected to increase rapidly, with the aging of the baby boomers, to one in five by 2030 (Ortman, Velkoff, & Hogan, 2014). Underlying this demographic transition are potentially major implications for health—at both the individual and population level. At the individual level, health decline and health-related problems in later life are considered to be part of a normal aging process. However, it is well-documented that poor health negatively influences one's quality of life, which is recognized as a primary life goal in developed countries (Graham, 2008; Stiglitz, Sen, & Fitoussi, 2009). At the population level, health promotion is a national priority. However, health care costs and expenditures are often viewed as burdensome. For example, total health expenditures in 2014 surpassed three-trillion dollars, or nearly 18% of gross domestic product in the U.S. Moreover, a large proportion (e.g., 50% with Medicare only) of health care costs among middle to older aged adults is covered by federal health insurance programs (Centers for Medicare & Medicaid Services, 2016; Lind, 2012). Given the large health care costs that disproportionately occur in middle and later-life, the federal government has pushed for initiatives aimed at enabling individuals to take more responsibility for their own health (U.S. Department of Health and Human Services, 2014).

Indeed, national health goals explicitly emphasize that all U.S. residents in general, and older adults in particular, need to focus on self-management of chronic conditions (U.S. Department of Health and Human Services, 2014). In turn, recent research has emphasized the importance of considering health literacy (e.g., the ability to understand and use health information) in empowering older individuals to more actively engage in prevention and self-care activities (Scott, Gazmararian, Williams, & Baker, 2002). The detailed components of health literacy are yet to be more clearly identified but print (e.g., reading, writing, numeracy), communication (e.g., listing, speaking) and information-seeking literacy are thought to be the main components (Squiers, Peinado, Berkman, Boudewyns, & McCormack, 2012). It should also be noted that health literacy is built on general literacy. In other words, without sufficient general literacy, acquiring greater health literacy skills is challenging. Mounting evidence shows that health literacy is one of the keys toward empowering people to take on their own health maintenance and promotion, but detailed mechanisms for how health literacy leads to health-related behaviors and/or health outcomes are yet to be confirmed (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011). Importantly, overall literacy skills in general, and health literacy skills specifically, tend to decline with aging (Centers for Disease Control and Prevention, 2009; Rampey et al., 2016b). In addition, the cumulative advantage/disadvantage theory suggests the differential health resources such as health literacy manifests in the health outcomes particularly in later life (e.g., Dannefer, 2003). Therefore, health literacy research that investigates specific components is needed to disentangle the complex effects of health literacy on self-care and prevention among vulnerable older populations.

Numeracy skills and health literacy

Numeracy skills, which reflect one's "ability to access, use, interpret, and communicate mathematical information and ideas, to engage in and manage mathematical demands of a range of situations in adult life" (PIAAC Numeracy Expert Group, 2009), are among the most critical, yet often overlooked, elements of health literacy. Health literacy is generally concerned with

overall health information, and one of its components -- numeracy is specifically concerned with quantitative health information. In fact, health literacy is derived from the health-related components of general literacy measures in the previous research (see National Assessment of Adult Literacy NAAL and PIAAC; Kutner et al., 2007). Emerging empirical evidence shows that numeracy skills are associated with a number of health-related outcomes and behaviors (Berkman et al., 2011; Feinberg, Greenberg, & Frijters, 2015). For example, numeracy is predictive of comprehension of numeric health information (e.g., lower numeracy is linked to the underestimation of the health risks) (Pires, Vigário, & Cavaco, 2016; Sinayev, Peters, Tusler, & Fraenkel, 2015). Also, limited numeracy skills are linked to poorer diabetes self-management, medication compliance, health knowledge, and communication in health care settings (Apter et al., 2008; Ginde, Clark, Goldstein, & Camargo Jr, 2008; Nelson, Reyna, Fagerlin, Lipkus, & Peters, 2008; Yee & Simon, 2014). Additionally, limited numeracy skills are associated with greater use of the emergency department, and increased rates of hospitalization and hospital recidivism (Apter et al., 2006; Apter et al., 2008; McNaughton et al., 2013). Thus, it is clear that numeracy skills are important for overall health and health-related behaviors. Yet, specific pathways between numeracy skills and health-related outcomes and behaviors are unclear, although some promising links are worth noting.

Numeracy skills and health information

Numeracy skills are related to the identification and comprehension of credible health information necessary for important decision making in health care and disease management (Peters, Hibbard, Slovic, & Dieckmann, 2007). Kerr (2010) explains that chronic disease management often requires the use of multiple numeracy skills, such as counting, calculating, and estimating. By the same token, adherence to preventive health behaviors requires advanced numeracy skills to accurately estimate both short and long-term relative and absolute risks (Apter et al., 2008; Peters et al., 2007). Numeracy skills have also become increasingly important in technology and information rich societies due to advancements in medicine, public health, and health communications (e.g., internet). Additionally, quantitative health information has rapidly increased over time, is now more quickly disseminated, and has become more complex than ever before (Ancker & Kaufman, 2007; Rampey et al., 2016a; Zarcadoolas, Pleasant, & Greer, 2009). As such, a better understanding of how numeracy is associated with the use of health-information is critical for advancing the discussion surrounding health education and communication.

Numeracy, health information, and preventive behaviors

Taken together, more empirical research on numeracy skills that focuses on preventive health and health information seeking behaviors should be conducted. In light of population aging and increasing health expenditures among middle and older aged adults, it is logical to target older populations with relatively lower numeracy compared to younger populations. Existing literature offers important theoretical insights into the role of numeracy, especially as related to health information and preventive health behaviors. Numeracy skills are essential for understanding the benefits of preventive health behaviors and the risks of potential adverse health outcomes. However, unlike observing outcomes associated with some medical treatments (e.g., drug therapy, antibiotics, etc.), observing outcomes associated with preventive health behaviors typically takes a substantially longer time. As such, people with limited numeracy skills may face challenges in understanding long-term health risks, and, therefore, preventive

health behaviors (e.g., regular checkup) may be put off until health care is urgently needed (Reyna, Nelson, Han, & Dieckmann, 2009).

Preventive health behaviors are demanding in terms of numeracy-related tasks. For example, individual decisions regarding health-related behaviors are often based on estimated benefits associated with a given behavioral change, and these benefits typically depend on how often and/or how much a given behavior is modified (Apter et al., 2008; Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005). Additionally, numeracy skills are essential for adherence to medication instructions, and medication use is relatively common among middle and older aged adults who often have chronic health issues (Osborn et al., 2013). This is especially important to consider, given that under- or over-dosing could easily result in an immediate health threat (Rothman, Montori, Cherrington, & Pignone, 2008). Moreover, adults with low numeracy skills may face disadvantages in certain health care situations, such as scheduling an appointment and applying for financial assistance (Nelson et al., 2008). In this context, numeracy skills are indispensable to correctly identify and comprehend a large amount of health information, and to make optimal health-related decisions. In fact, an emerging body of evidence has shown that population health disparities are partially driven by socioeconomic gradients in the ability of certain subgroups (i.e., education level, and race/ethnicity) to perform a series of quantitative health decision making tasks (Institute of Medicine, 2004; Kutner et al., 2007; McNaughton et al., 2013; Yee & Simon, 2014).

Next steps in numeracy and health research

Based on the health information-seeking and preventive health behaviors literature, we have identified three logical steps to advance the current knowledge surrounding numeracy skills. First, numeracy skills, as a component of health literacy, are understudied compared to written and oral literacy skills. Therefore, foundational empirical evidence is needed to identify pathways that link numeracy with health behaviors and outcomes (Al Sayah, Majumdar, Williams, Robertson, & Johnson, 2013; Berkman et al., 2011; Golbeck et al., 2005). In particular, the critical role (e.g., risk and benefit perception) that numeracy plays in health outcomes is at the early stage of development in the literature. Second, although health literacy is a national health goal, nationally representative (e.g., generalizable) evidence from related research is scant (Sheridan et al., 2011). For example, much of the previous research is at the local level (i.e., community), and/or limited to select health care settings (e.g., Medicare patients, patients at local medical centers and clinics; McNaughton et al., 2013; Osborn, Cavanaugh, Wallston, & Rothman, 2010), which is at least partially due to the limited availability of nationally representative data on numeracy skills. In fact, research often depends on the public availability of datasets—including the International Adult Literacy Survey (IALS), National Assessment of Adult Literacy (NAAL), and Adult Literacy and Life skill (ALL) survey, which were conducted in 1990s and 2000s (Burns, Wang, & Henning, 2011). Finally, health generally declines with age, and older individuals are at relatively higher risk of health-related problems. Yet, the role of numeracy skills in the context of health behaviors and outcomes among middle to older aged adults remains largely unknown.

Research questions

This study utilized a recently published and nationally representative dataset to address the aforementioned gaps among middle to older aged adults (45 to 74 years). The PIAAC data

(Rampey et al., 2016b) provides a unique opportunity to examine numeracy skills and health behavior. Specific areas of inquiry include: (a) detailed demographic, socioeconomic, and health characteristics in terms of numeracy skills, and (b) the role of numeracy skills in the context of health information-seeking and preventive health behaviors. The purpose of this research is to provide baseline empirical findings for future health numeracy research. Our analyses were guided by the three following research questions (RQ):

RQ1: Are there differences in numeracy skills across subgroups of middle to older aged adults by demographic, socioeconomic, and health characteristics?

To address this question, we estimated numeracy skill levels by age groups, gender, race/ethnicity, educational attainment, health status, and numeracy skill use at home.

RQ2: Are numeracy skills associated with the information sources which the middle to older aged adults use to obtain health information?

We used a series of regression models to determine how numeracy skills are associated with the information source individuals obtain health information. Possible sources included health professionals, the internet, television, friends and family, books, newspapers, magazines, and radio.

RQ3: Are numeracy skills among middle to older aged adults associated with adherence to recommended preventive health behaviors?

We used a series of regression models to determine whether and how numeracy skills are associated with the selected modifiable preventive health behaviors including flu shot, dental checkup, vision screening, and osteoporosis screening. Other common preventive health behaviors, such as cancer screenings, are not easily reflected in subsequent behavior changes and thus were not included.

Methods

Data

The data were obtained from the 2012/2014 Program for the International Assessment of Adult Competencies (PIAAC) (Rampey et al., 2016b). The analytic sample was restricted to middle to older aged adults (age 45-74 years old) in the U.S. The PIAAC was designed to collect nationally representative and internationally comparable data on skill indicators such as literacy, numeracy, and problem-solving. The data also include detailed information on sociodemographic characteristics, activities/behaviors (e.g., reading, writing, preventive health behaviors), and health status. The PIAAC initially focused on national populations between the ages of sixteen and sixty-five-years old. However, the recently released 2014 U.S. data include older adults (those ages 66 to 74-years old) in addition to the regular PIAAC participants (Rampey et al., 2016b). Therefore, the latest wave of PIAAC data provides a unique opportunity to examine associations between numeracy skills and health behaviors among middle to older aged adults.

Age forty-five was selected as the initial cut-point because it is commonly used to define the point at which the second half of adult life, or pre-retirement phase, begins (e.g., Ekerdt, 2010). The initial sample size was 3,279 respondents ages 45-74 years old. Missing values in any variable of interest were handled using listwise deletion (n = 290, 8.84%), which resulted in an analytic sample of 2,989 respondents. On a related note, the final analytic sample (i.e., any missing values were excluded) was based on the fully conditional model, and therefore, the descriptive statistics (i.e., missing values only in the variable of interest were excluded) may show some differences in sample size. In addition, our detailed examinations of the missing data revealed no systematic patters, and thus, we assumed that the missing values are random.

Measures

Numeracy skills. Based on a set of 10 plausible values and suggested cut-points in the PIAAC (OECD, 2012), numeracy skill levels are represented by a 5-point numeracy proficiency scale (i.e., 0 to 4 [Below Level 1; Level 1; Level 2; Level 3; Level 4 & 5]). Higher levels indicate greater competency. Due to an insufficient sample size in the highest level of proficiency, Level 4 and 5 were combined to collectively reflect the highest proficiency level. Moreover, two additional classifications including a 3-point proficiency scale (i.e., low, medium, and high proficiency [Below Level 1 & Level 1 vs. Level 2 vs. Level 3, Level 4 & Level 5]) and a 2-point proficiency scale (i.e., low vs. medium & high proficiency [Below Level 1 & Level 1 vs. Level 2 to 5]) were used to further address research question 2 and 3. A set of 10 plausible numeracy skill levels was used in the specialized program (SAS macro program: discussed in the analytic approach section) to estimate the descriptive statistics as well as regression models.

Health information sources. Based on the survey question "How much information about health issues do you get from…?", the amount of health information individuals obtained from each of the eight sources including health professionals, the internet, television, friends and family, books, newspapers, magazines, and radio, was recorded on a dichotomous scale (i.e., none & a little vs. some, & a lot). The decision on dichotomizing the variable was based on the data distributions (see Tables 2.1 through 2.4) and interpretability of results in the preliminary analysis.

Preventive health behaviors. A dichotomous variable (i.e., yes vs. no) was created for each of the selected preventive health behaviors to indicate whether respondents respectively received a flu shot, dental checkup, vision screening, or osteoporosis screening in the past year.

Covariates. A series of dichotomous variables were constructed for the demographic, socioeconomic, and health measures: gender (1 = female; 0 = male), race (1 = white; 0 = non-white), educational attainment (1 = college or higher; 0 = less than college), health status (1 = good health; 0 = poor health). Health status, due to its skewed distribution, was dichotomized based on its original 5-point scale (i.e., excellent, very good, and good vs. fair and poor). Age was recorded with the use of indicator variables that denote six approximate five-year age groups (i.e., 45-49, 50-54, 55-59, 60-65, 66-70 and 71-74). A measure for the use of numeracy skills at home was constructed based on responses to six numeracy-related items (i.e., calculating prices, costs or budgets; use of fractions, decimals, or percentages; use of calculators; preparing graphs or tables; algebra or formulas; use of advanced math or statistics, such as calculus or

trigonometry) (OECD, 2016). The PIAAC-derived index for this measure was utilized, which ordered numeracy skill use into quintiles (i.e., 1 to 6; 1 = no/least use; to 6 = greatest use among PIAAC respondents). In addition to this robust set of covariates, we also control for literacy proficiency in RQ2 and RQ3, which is based on PIAAC-derived levels that range from 0 to 4 (i.e., Below Level 1; Level 1; Level 2; Level 3; Level 4 & 5). Further, additional classifications were also considered (i.e., 3-point, and 2-point literacy levels; similar to the numeracy skill levels). These plausible literacy proficiency levels were only used in regression analysis and select descriptive statistics, as some descriptive statistics were not possible to compute given existing software limitations.

Analytic approach

Descriptive statistics were computed using the final sampling weight (SPFWT0) and 80 replicate weights (SPFWT1-SPFWT80). SAS macro programs generated by the IDB Analyzer application version 4.0.8 (IEA, 2016) were utilized to correctly implement the sampling weights and conduct statistical estimation with the use of plausible values for accurate estimation of parameters and standard errors.

Unconditional binary logistic regression was used to determine statistical significance in bivariate tests (i.e., Wald chi-square test) for all variables by the numeracy levels. Binary logistic regression was used to model each of the eight health information sources (i.e., none & a little vs. some & a lot), respectively, as a function of numeracy skills accounting for all covariates. Binary logistic regression was also used to estimate the association between numeracy skills and preventive health behaviors (i.e., flu shot, dental checkup, vision screening, and osteoporosis screening) accounting for all covariates. In RQ 2 and RQ3, the different measurement strategies for numeracy skills (i.e., 5-, 3-, and 2-point proficiency levels) were explored. The sampling and replicate weights were incorporated into all analyses, and statistical significance was evaluated at the alpha level of 0.05 (see Appendix 1).

[Insert Exhibit A here]

Results

Sociodemographic profile of numeracy skills (RQ1)

[Insert Table 1.1 Here]

Approximately 80% of respondents are between the ages of forty-five and sixty-five years old, 12% are sixty-six to seventy, and almost 7% are seventy-one years old or older. Slightly over 50% of the sample is female. Approximately 73% are white, 40% have a college education or higher, 75% are employed, and 75% rate their health as good or better. Approximately 11% of respondents reported that they do not use numeracy skills at home. Overall, numeracy skills are approximately normally distributed, the below level 1 to Level 4 & 5, had roughly 11%, 22%, 33%, 26% and 8%, respectively. Table 1.1 shows the distribution of numeracy skill levels by each variable of interest (i.e., demographic, socioeconomic, health

status, and numeracy skill use at home), and the bivariate tests for statistical significance are summarized in Table 1.2.

[Insert Table 1.2 Here]

Results from bivariate tests are based on unconditional generalized linear models derived from SAS programs produced by the IDB analyzer (see Table 1.2). Thus, to avoid misinterpretation of results, we simply report statistical significance (i.e., $p < 0.05$) and the direction of the bivariate associations (i.e., negative or positive), rather than the estimated coefficients for each model. Numeracy skills were found to differ across demographic groups. Specifically, numeracy skills are negatively associated with age, women have lower numeracy skills compared to men, and whites have higher numeracy skills compared to non-whites. Numeracy skills also differ by socioeconomic characteristics, such that those with a college education have higher levels of numeracy compared to those with less than a college degree, and those who are currently employed have higher levels of numeracy compared to those who are not, on average. Health also was associated with the distribution of numeracy skill levels, as individuals with good health tend to have greater numeracy skills compared to those with poor health. Furthermore, numeracy levels are positively associated with the use of numeracy skills at home.

Health information sources and numeracy skills (RQ2)

[Insert Tables 2.1 through 2.4 Here]

Tables 2.1 through 2.4 show the distribution of health information sources for the full sample, and by demographic, socioeconomic, and health characteristics, numeracy skill level, and numeracy skill use at home. Overall, the most common source that individuals obtain "a lot" of health information from is health professionals (49%), followed by the internet (36%), television (31%), friends and family (21%), books (16%), radio (9%), newspapers (9%), and magazines (9%). Approximately 25-50% of respondents reported that they obtain "some" health information from each of the eight sources, respectively. Given the response "none" or "a little," the least common sources for health information are radio (63%), newspapers (60%), and magazines (53%). Tables 2.5 through 2.12 show results from fully conditional binary logistic regression models that were used to estimate associations between respective health information sources and each variable of interest.

[Insert Tables 2.5 through 2.12 Here]

Only 4 of the 8 health information sources were statistically significantly associated with numeracy skills at the 0.05 level. Specifically, those with medium to high numeracy proficiency are less likely to use, magazines, television, books, or newspapers as sources for health information, net of accounting for the demographic characteristics, socioeconomic status, health status, use of numeracy skills at home, and literacy level. Other health information sources including health professional, internet, radio and social network, were not associated with numeracy skill levels. Notably, the medium to high literacy proficiency was associated with greater use of health professional and internet as health information sources.

Preventive health behaviors and numeracy skills (RQ3)

[Insert Table 3.1 here]

Table 3.1 shows the distribution of preventive health behaviors, as well as the results from bivariate statistical significance tests i.e., (Wald chi-square test). Overall, approximately 50% of respondents received a flu shot, nearly 70% had a dental checkup, slightly over 60% had a vision screening, and 25% received an osteoporosis screening in the year prior to the survey date. The results from bivariate statistical significance tests indicated that middle-aged and older respondents (ages 45-74) were more likely to have had a flu shot, vision screening, and osteoporosis screening, but less likely to have a dental checkup, compared to younger respondents. Females were more likely than males to have had received a flu shot, dental checkup, vision screening, or osteoporosis screening. Whites were more likely than non-whites to have had a dental checkup, but less likely to have had an osteoporosis screening. However, no appreciable racial differences in the distribution of flu shots or vision screenings were observed. Those with a college education were more likely than those with less than a college education to have had received a flu shot, dental checkup, vision screening, or osteoporosis screening in the past year. Individuals who are employed were more likely to have had a dental checkup, but less likely to have had a flu shot or an osteoporosis screening compared to those who are not employed. Vision screenings did not differ by employment status. Respondents with good or better health were more likely to have had a dental checkup or vision screening, but less likely to have had an osteoporosis screening, compared to those with fair or poor health. Flu shots did not differ by health status. Those with greater numeracy skills were more likely to have had a dental checkup and osteoporosis screening. Literacy skills were only statistically significantly associated with the dental checkup. Furthermore, numeracy skill use at home was positively associated with having had a flu shot, dental checkup, or vision screening, but not an osteoporosis screening.

[Insert Tables 3.2 through 3.5 Here]

Tables 3.2 through 3.5 show results from binary logistic regression models used to respectively predict each of the four preventive health behaviors. Sensitivity analyses based on a comparison of results from models that utilized numeracy skill levels based on 5-point, 3-point, 2-point scales indicated that the 2-point numeracy scale produced the best fitting model. Therefore, results reported in Tables 3.2 through 3.5 were derived from models that utilized the 2-point numeracy scale. Additionally, we utilized a stepped modeling approach, where numeracy level, literacy level, and all other variables were sequentially tested. Unconditional results (i.e., Model 1 and 2) indicated that those with low numeracy skills or low literacy skills were less likely compared to those with medium to high proficiency to have had a dental checkup. However, the fully conditional results (i.e., Model 3) show that dental checkups were positively associated with numeracy skills, but not statistically associated with literacy skills. The 2-point scale for numeracy skills was positively associated with having had an osteoporosis checkup in the unconditional model, but this is fully attenuated in the fully conditional model. In sum, numeracy skills were not associated with having had a flu shot or vision checkup in either the unconditional or fully conditional models.

Discussion: summary of findings

Sociodemographic profile of numeracy skills

The present study is one of the first to examine numeracy skills among a nationally representative sample of middle and older aged adults in the U.S. Thus, the sociodemographic profile of numeracy skills provided in this study represents a foundation from which future research should build on. Current results indicated that numeracy skills systematically differ by age, sex, race, education, employment status, self-rated health, and numeracy skill use at home in middle to later life. In the following paragraphs, we critically assess how these sociodemographic findings can be interpreted, and we provide insights into how they may guide and help advance future research on the relationship between numeracy skills and health behaviors and outcomes.

There is some evidence, given age patterns observed in this study, to suggest that numeracy skills may decline in the later life course (OECD, 2013). Also, in light of the cumulative advantage/disadvantage theory, the gap in numeracy may become more visible in the form of health outcomes in later life (Dannefer, 2003). However, given data limitations (e.g., only cross-sectional data were available to this study focusing on the U.S. samples), it is not possible to rule out potential cohort effects. In other words, the relatively higher numeracy skills observed among younger age groups (i.e., more recent cohorts among the existing middle-aged and older populations) may not be entirely due to an underlying aging process, but simply their relatively higher numeracy could be related to historical trends in educational attainment and technological advancements. Indeed, more recent cohorts are potentially more likely to have had relatively greater access to education and/or opportunities to improve numeracy skills. Unfortunately, multiple waves of cross-sectional, or longitudinal panel data are needed to further tease apart the relationship between numeracy skills and age. Future research, given that such data are not yet available, may find it beneficial to focus on within-cohort differences. For example, the baby boomer cohort is particularly interesting because of its relatively large size and within-group heterogeneity (e.g., this cohort is arguably more racially/ethnically diverse compared to earlier birth cohorts).

The potential embeddedness of age and cohort effects is also important to consider in light of the present study's results in terms of numeracy skill levels across sex and race groups. Specifically, gender difference in numeracy skills, which favored males, may appear exceptionally large given the focus on middle to older aged adults. Specifically, women's increasing trends in education may have narrowed, or even closed, this gap among more recent cohorts. Furthermore, whites were found to have substantially higher numeracy skills compared non-whites, and racial disparities in access to education have substantially narrowed over time. Despite narrowing racial inequalities in educational attainment, much future research is needed to examine the role of race/ethnicity in the context of numeracy and health-related outcomes. To this regard, one limitation of the current study was that more detailed race/ethnic groupings (e.g., non-Hispanic black, Hispanics, Asians, etc.) were not available due to their limited sample size.

Future research should, if/when possible, investigate race/ethnic sub-group differences in numeracy skills.

Unsurprisingly, numeracy skills were found to be greater among those with at least a college education compared to those with less than a college education. Indeed, the national data have consistently shown the positive associations between the formal education and literacy skills (e.g., Kutner et al., 2007). However, whether or not numeracy skills are adaptable after traditional educational attainment is established (e.g., through lifelong learning activities) remains a question worth pursuing. In the same vein, results related to employment status and numeracy skill use at home suggest that continuing active engagement in middle to later adulthood may in fact be beneficial for maintaining/improving numeracy skills. Furthermore, future studies should explore the causal pathways between numeracy skills and health, as this relationship is likely bidirectional. For example, there are strong theoretical arguments to suggest that relatively lower numeracy skills lead to poor health outcomes, and vice versa. Therefore, the association between numeracy skill use and health requires further investigation, as declining health may necessitate the use of numeracy skills to understand complex health-related information.

Health information sources and numeracy skills

Medium to high numeracy proficiency was found to be negatively associated, at least partially, with the amount of health information individuals obtained from magazines, televisions, books, and newspapers after accounting for all relevant covariates. Therefore, these findings suggest that numeracy and literacy likely play distinct roles in the context of specific sources that individuals utilize to obtain health information. The U.S. has experienced rapid advancements in information and communication technology, as well as the amount of information available to the public (Zarcadoolas et al., 2009), and health information is not an exception. Therefore, this rapidly advancing environment may pose unique challenges for those with relatively lower numeracy skills. Moreover, magazines, television, books, and newspaper generally reflect traditional sources of health information. Accordingly, middle to older aged adults may be more familiar with these health information sources compared to more recent (e.g., non-traditional) sources of health information, such as the internet.

Findings that individuals with low numeracy proficiency tend to rely on traditional sources of health information further emphasize the importance of disentangling age and cohort effects. For example, crystalized intelligence generally declines in later adulthood (Bugg, Zook, DeLosh, Davalos, & Davis, 2006), and the current study showed that numeracy skills were negatively associated with age. In conjunction, it is possible that middle to older aged adults may seek health information from sources that they were familiar with (e.g., sources that are less challenging to access, navigate, and interpret). However, given the cross-sectional nature of the present study, we were unable to test whether the relatively greater use of familiar/traditional sources of health information among middle to older aged adults with low numeracy proficiency was due to age-related declines in numeracy skills. This limitation highlights the need for nationally representative longitudinal panel data that includes information for numeracy skills and health behaviors and outcomes.

Furthermore, future research should refine the measurement of health information source. Given the subjective nature of the data, and no ideal method to more specifically quantify health information consumptions, it may be beneficial for future research to consider other measurement strategies (e.g., rankings) and qualitative inquiry (e.g., in-depth interview about the best health information source) in terms of health information source and utilization. Additional effort is also warranted to identify pathways between numeracy, health information source and specific health outcomes.

Preventive health behaviors and numeracy skills

Numeracy skills were positively associated with having had a dental checkup, but not with having had a flu shot, vision screening, or osteoporosis screening in the past year, accounting for all relevant covariates. Knowledge surrounding numeracy skills and preventive health behaviors is relatively scant, but there are a few possible explanations for these findings. For example, among the four preventive health behaviors (i.e., dental checkup, flu shot, vision screening, and osteoporosis screening), only having had a dental checkup was independent of age. This suggests that dental health behaviors may be established in early adulthood and carried forward into middle and later life, while the other preventive health behaviors are relatively more strongly encouraged and promoted among older populations (Feinberg et al., 2015). This is further supported by current evidence that numeracy skills are more likely to decrease opposed to increase as one ages into the later years of life, which is consistent with the idea that individuals with greater numeracy skills might have established their dental health behaviors early on in their life course. In the same vein, high levels of numeracy skills are likely necessary for developing an understanding about dental risk factors (e.g., plaque buildup) and their long-term consequences (e.g., extensive dental treatment and its related costs).

Another possible explanation could be that some health risks are generally viewed as more preventable compared to others. For example, dental health problems may be more preventable through regular checkups and regular self-care (e.g., brushing and flossing) compared to eye disease and bone-related issues. Dental check-ups also prevent more serious and deterioration of dental health problems at earlier stages (i.e., secondary and tertiary preventions) over the life course (Thomson, Williams, Broadbent, Poulton, & Locker, 2010). Additionally, estimating the risk associated with contracting the flu is arguably more short-term and less complicated than estimating risks associated with dental health. The feasibility of prevention can be seen as a propensity for achieving optimal health. Perhaps, middle to older aged adults prioritize more preventable and immediate health issues and, therefore, use their numeracy skills to decide whether or not to obtain dental care services. This notion is supported by the significant relationship between the use of numeracy skills at home and dental care service use. On the same note, both use of numeracy skills at home and dental health service use may be explained by need factors (i.e., dental health problems). When an older adult faces a serious dental or orthodontic/periodontal disease, he or she may become motivated to use numeracy skills as well as dental health services to address the issue. More comprehensive examination of the role of numeracy in preventive health behaviors is certainly needed.

Limitations

Several limitations in this study should be acknowledged. Possible omitted variable bias cannot be ruled out. For example, some traditional demographic characteristics such as marital status, income, and detailed health conditions (e.g., previous diagnosis of osteoporosis, dental health problems, etc.) were not available in the PIAAC data. Additionally, due to the limited sample size, detailed analyses of age, race/ethnicity, educational attainment, and employment status were not possible. Although these factors were not the major focus of this study, present results may require cautious interpretation in relation to internal validity. Moreover, the analytic strategy was restricted to functions provided by the IDB Analyzer (IEA, 2016). As such, more complex modeling such as cluster analysis and structural equation models with multiple outcome variables was beyond the scope of this study. This issue is particularly relevant for developing a deeper understanding of numeracy skills and their association with health information sources, as some of the information source may be highly correlated (e.g., use of books and magazine, use of social network and health professionals). Future research should examine correlations between different health information sources (Feinberg et al., 2015). Furthermore, the analyses for preventive health behaviors were somewhat data driven. Particularly, the measurement of numeracy levels lacks a rigorous theoretical basis, although the exploration of different measurement strategies in this study reflects an advancement toward this goal. In fact, a possible tipping point of the numeracy effect on the preventive health behaviors was identified. Finally, despite the fact that the major aim of this study was to explore some of the first nationally representative data that includes important information on an understudied topic—numeracy and health information seeking and preventive health behaviors—the identification of potential pathways was limited given the lack of existing evidence. However, our findings represent a substantial advancement in current knowledge surrounding numeracy skills and their association with health behaviors, and our interpretation of results provided specific strategies that researchers should find useful for guiding future research.

Contributions and directions for future research

This study made at least four important contributions. First, this study provided a nationally representative profile of numeracy skills by demographic, socioeconomic, and health characteristics for an understudied population of middle to older aged adults. These detailed descriptive statistics represent baseline findings that should be useful for policy discussion as well as future research on numeracy and health literacy. Second, findings about the role of numeracy in the use of health information sources and preventive health behaviors complements the related health literacy literature. Given the empirical associations between numeracy skills and use of health information sources and preventive health behaviors identified in this study, a next logical step is to examine the potential pathways in more detail. Third, the rigorous exploration of different numeracy level measurement strategies (e.g., 5-point, 3-piont, and 2-point proficiency levels) provided evidence for a possible threshold effect in relation to preventive health behaviors. Lastly, the use of PIAAC survey sampling and replicate weights, the plausible values using IDB Analyzer (IEA, 2016) to compute numeracy skill levels can be easily replicated in future research. Detailed descriptions of the methods should be useful for researchers who are not yet familiar with the PIAAC data.

Preliminary policy implications

Findings from the current study shed light on the potential linkage between numeracy skills and population health disparities through health information access and preventive health behavior. These preliminary findings should encourage policy discussion surrounding inequalities in the access and utilization of up-to-date comprehensive health information and preventive health service. Relatedly, the accessibility to, and numeracy required for comprehending, preventive health information is likely related to the source from which health information is delivered (e.g., internet, book, health professionals). As such, education and health policies should ensure that trustworthy health information is readily available to diverse middle-aged and older populations with a range of numeracy proficiencies. Particularly, policy-based and community-based efforts to provide customized health information to middle and older aged adults who are at the risk of health information disadvantage due to insufficient numeracy skills could be targeted to avoid the misinterpretation of health information, for example, in books, magazines, newspaper and TV. In-depth analysis of how adults with low numeracy proficiency levels perceive numeric health information through rigorous qualitative research would be useful to inform the future development of health communication strategies. Additionally, providing education programs focusing on how to interpret numeracy-intense health information in health care settings may be beneficial. Possible ideas include use of simpler message, information that requires less calculation and visual aids (Peters et al., 2007). Such efforts could also be extended to community centers, public senior centers, and general education settings, and health care providers should be encouraged to be involved in their design and intervention programs.

As the underlying pathways linking numeracy, health information seeking and preventive health behaviors unfold in future research, intervention research would become increasingly feasible and of substantial value. Yet, researchers are presently faced with the challenge of lacking nationally representative data on health literacy in general, and numeracy skills in particular. As such, data collection efforts, such as those reflected in the PIAAC, require continuous support from both public and private organizations. Such data, if they become available, will enable researchers to better identify and understand potential pathways to optimal health through health literacy. Furthermore, future data collection should include more detailed demographic and socioeconomic information, as well as information regarding health behaviors, health care utilization, and health and well-being outcomes.

Summary

Numeracy skills have been studied less extensively compared to general literacy and health literacy in the context of public health and education. Furthermore, given a lack of previous data that included middle aged to older adults, much was unknown about numeracy skills and health behaviors in the later end of the life course, where health problems and health care spending are largely concentrated. This study analyzed the nationally representative PIAAC data and found that medium to high numeracy proficiency is predictive of less frequent use of magazines, books, television, and newspaper as health information sources. Additionally, greater numeracy was found to predict the use of routine dental care. Although the pathways between numeracy skills and the use of specific health information sources and preventive health behaviors are yet to be identified, findings from the current study represent some of the first nationally representative empirical evidence from which related research may build upon and policy discussions may be informed.

References

Al Sayah, F., Majumdar, S. R., Williams, B., Robertson, S., & Johnson, J. A. (2013). Health Literacy and Health Outcomes in Diabetes: A Systematic Review. *Journal of General Internal Medicine, 28*(3), 444-452. doi:10.1007/s11606-012-2241-z

Ancker, J. S., & Kaufman, D. (2007). Rethinking Health Numeracy: A Multidisciplinary Literature Review. *Journal of the American Medical Informatics Association, 14*(6), 713-721. doi:10.1197/jamia.M2464

Apter, A. J., Cheng, J., Small, D., Bennett, I. M., Albert, C., Fein, D. G., . . . Van Horne, S. (2006). Asthma Numeracy Skill and Health Literacy. *Journal of Asthma, 43*(9), 705-710. doi:10.1080/02770900600925585

Apter, A. J., Paasche-Orlow, M. K., Remillard, J. T., Bennett, I. M., Ben-Joseph, E. P., Batista, R. M., . . . Rudd, R. E. (2008). Numeracy and Communication with Patients: They Are Counting on Us. *Journal of General Internal Medicine, 23*(12), 2117-2124. doi:10.1007/s11606-008-0803-x

Berkman, N. D., Sheridan, S. L., Donahue, K. E., Halpern, D. J., & Crotty, K. (2011). Low health literacy and health outcomes: An updated systematic review. *Annals of Internal Medicine, 155*(2), 97-107. doi:10.7326/0003-4819-155-2-201107190-00005

Bugg, J. M., Zook, N. A., DeLosh, E. L., Davalos, D. B., & Davis, H. P. (2006). Age differences in fluid intelligence: Contributions of general slowing and frontal decline. *Brain and Cognition, 62*(1), 9-16. doi:http://dx.doi.org/10.1016/j.bandc.2006.02.006

Burns, S., Wang, X., & Henning, A. (2011). *NCES handbook of survey methods*. Retrieved from Washington, DC: https://nces.ed.gov/pubs2011/2011609_1.pdf

Centers for Disease Control and Prevention. (2009). *Improving health literacy for older adults: Expert panel report 2009*. Retrieved from Atlanta, GA: https://www.cdc.gov/healthliteracy/pdf/olderadults.pdf

Centers for Medicare & Medicaid Services. (2016). NHE fact sheet. Retrieved from https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nhe-fact-sheet.html

Dannefer, D. (2003). Cumulative advantage/disadvantage and the life course: Cross-fertilizing age and social science theory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58*(6), S327-S337.

Ekerdt, D. J. (2010). Frontiers of Research on Work and Retirement. *The Journals of Gerontology: Series B, 65B*(1), 69-80. doi:10.1093/geronb/gbp109

Feinberg, I., Greenberg, D., & Frijters, J. (2015). *Understanding health information seeking behaviors of adults with low literacy, numeracy, and problem solving skills: Results from the 2012 us PIAAC study*. Retrieved from Washington, DC: https://static1.squarespace.com/static/51bb74b8e4b0139570ddf020/t/54da7889e4b004762df45b52/1423603849970/Feinberg_Greenberg_Frijters_PIAAC.pdf

Ginde, A. A., Clark, S., Goldstein, J. N., & Camargo Jr, C. A. (2008). Demographic disparities in numeracy among emergency department patients: Evidence from two multicenter studies. *Patient Education and Counseling, 72*(2), 350-356. doi:http://dx.doi.org/10.1016/j.pec.2008.03.012

Golbeck, A. L., Ahlers-Schmidt, C. R., Paschal, A. M., & Dismuke, S. E. (2005). A Definition and Operational Framework for Health Numeracy. *American Journal of Preventive Medicine, 29*(4), 375-376. doi:http://dx.doi.org/10.1016/j.amepre.2005.06.012

Graham, C. (2008). Happiness And Health: Lessons—And Questions—For Public Policy. *Health Affairs, 27*(1), 72-87. doi:10.1377/hlthaff.27.1.72

IEA. (2016). Help manual for the IDB analyzer (SAS macros). . Hamburg, Germany. Retrieved from http://www.iea.nl/data

Institute of Medicine. (2004). *Health literacy: a prescription to end confusion*. Washington, DC: National Academy Press.

Kerr, D. (2010). Poor numeracy: the elephant in the diabetes technology room. *J Diabetes Sci Technol, 4*(6), 1284-1287.

Kutner, M., Greenberg, E., Jin, Y., Boyle, B., Hsu, Y., & Dunleavy, E. (2007). *Literacy in everyday life: Results from the 2003 National Assessment of Adult Literacy*. Retrieved from Washington, DC: http://nces.ed.gov/Pubs2007/2007480_1.pdf

Lind, K. D. (2012). *Setting the record straight about Medicare*. Retrieved from Washington, DC:

McNaughton, C. D., Collins, S. P., Kripalani, S., Rothman, R., Self, W. H., Jenkins, C., . . . Storrow, A. B. (2013). Low Numeracy Is Associated With Increased Odds of 30-Day Emergency Department or Hospital Recidivism for Patients With Acute Heart Failure. *Circulation: Heart Failure, 6*(1), 40-46. doi:10.1161/circheartfailure.112.969477

Nelson, W., Reyna, V. F., Fagerlin, A., Lipkus, I., & Peters, E. (2008). Clinical Implications of Numeracy: Theory and Practice. *Annals of Behavioral Medicine, 35*(3), 261-274. doi:10.1007/s12160-008-9037-8

OECD. (2012). *Literacy, numeracy and problem solving in technology-rich environments: Framework for the OECD Survey of Adult Skills*. Retrieved from http://www.oecd.org/skills/piaac/PIAAC%20Framework%202012--%20Revised%2028oct2013_ebook.pdf

OECD. (2013). *OECD skills outlook 2013: First results from the Survey of Adult Skills*. Retrieved from http://www.oecd.org/about/publishing/Corrigendum-OECD-skills-outlook-2013.pdf

Ortman, J. M., Velkoff, V. A., & Hogan, H. (2014). *The older popuation in the United States*. Retrieved from Washington, DC: https://www.census.gov/prod/2014pubs/p25-1140.pdf

Osborn, C. Y., Cavanaugh, K., Wallston, K. A., & Rothman, R. L. (2010). Self-Efficacy Links Health Literacy and Numeracy to Glycemic Control. *Journal of Health Communication, 15*(sup2), 146-158. doi:10.1080/10810730.2010.499980

Osborn, C. Y., Wallston, K. A., Shpigel, A., Cavanaugh, K., Kripalani, S., & Rothman, R. L. (2013). Development and Validation of the General Health Numeracy Test (GHNT). *Patient Education and Counseling, 91*(3), 350-356. doi:10.1016/j.pec.2013.01.001

Peters, E., Hibbard, J., Slovic, P., & Dieckmann, N. (2007). Numeracy Skill And The Communication, Comprehension, And Use Of Risk-Benefit Information. *Health Affairs, 26*(3), 741-748. doi:10.1377/hlthaff.26.3.741

PIAAC Numeracy Expert Group. (2009). *PIAAC numeracy: a conceptual framework*. Retrieved from Paris, France: http://www.oecd-ilibrary.org/docserver/download/220337421165.pdf?expires=1511105474&id=id&accname=guest&checksum=2296549ADC55AEDD55D4AF21CB983913

Pires, C., Vigário, M., & Cavaco, A. (2016). Factors influencing subjects' comprehension of a set of medicine package inserts. *International Journal of Clinical Pharmacy, 38*(4), 888-898. doi:10.1007/s11096-016-0305-6

Rampey, B. D., Finnegan, R., Goodman, M., Mohadjer, L., Krenzke, T., Hogan, J., & Provasnik, S. (2016a). *Skills of U.S. Unemployed, Young, and Older Adults in Sharper Focus:*

Results From the Program for the International Assessment of Adult Competencies (PIAAC) 2012/2014: First Look. Retrieved from Washington, DC: https://nces.ed.gov/pubs2016/2016039.pdf

Rampey, B. D., Finnegan, R., Goodman, M., Mohadjer, L., Krenzke, T., Hogan, J., & Provasnik, S. (2016b). *Skills of U.S. unemployed, young, and older adults in sharper focus: Results from the Program for the International Assessment of Adult Competencies (PIAAC) 2012/2014: First look* Retrieved from Washington, DC: https://nces.ed.gov/pubs2016/2016039.pdf

Reyna, V. F., Nelson, W. L., Han, P. K., & Dieckmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin, 135*(6), 943-973. doi:10.1037/a0017327

Rothman, R. L., Montori, V. M., Cherrington, A., & Pignone, M. P. (2008). Perspective: The Role of Numeracy in Health Care. *Journal of health communication, 13*(6), 583-595. doi:10.1080/10810730802281791

Scott, T. L., Gazmararian, J. A., Williams, M. V., & Baker, D. W. (2002). Health Literacy and Preventive Health Care Use Among Medicare Enrollees in a Managed Care Organization. *Medical Care, 40*(5), 395-404.

Sheridan, S. L., Halpern, D. J., Viera, A. J., Berkman, N. D., Donahue, K. E., & Crotty, K. (2011). Interventions for Individuals with Low Health Literacy: A Systematic Review. *Journal of Health Communication, 16*(sup3), 30-54. doi:10.1080/10810730.2011.604391

Sinayev, A., Peters, E., Tusler, M., & Fraenkel, L. (2015). Presenting Numeric Information with Percentages and Descriptive Risk Labels:A Randomized Trial. *Medical Decision Making, 35*(8), 937-947. doi:10.1177/0272989x15584922

Squiers, L., Peinado, S., Berkman, N., Boudewyns, V., & McCormack, L. (2012). The Health Literacy Skills Framework. *Journal of Health Communication, 17*(sup3), 30-54. doi:10.1080/10810730.2012.713442

Stiglitz, J., Sen, A., & Fitoussi, J.-P. (2009). The measurement of economic performance and social progress revisited. *Reflections and overview. Commission on the Measurement of Economic Performance and Social Progress, Paris*.

Thomson, W. M., Williams, S. M., Broadbent, J. M., Poulton, R., & Locker, D. (2010). Long-term Dental Visiting Patterns and Adult Oral Health. *Journal of Dental Research, 89*(3), 307-311. doi:10.1177/0022034509356779

U.S. Department of Health and Human Services. (2014). HealthyPeople.gov: older adults. Retrieved from https://www.healthypeople.gov/2020/topics-objectives/topic/older-adults

Yee, L. M., & Simon, M. A. (2014). The Role of Health Literacy and Numeracy in Contraceptive Decision-Making for Urban Chicago Women. *Journal of Community Health, 39*(2), 394-399. doi:10.1007/s10900-013-9777-7

Zarcadoolas, C., Pleasant, A., & Greer, D. S. (2009). *Advancing health literacy: A framework for understanding and action* (Vol. 45). San Francisco: John Wiley & Sons.

Exhibit A Summary of Analytic Approaches

Research question	Statistical model	Dependent variable	Independent Variable	Covariates
Descriptive	Weighted percentages	The set of 10 plausible numeracy skill levels (0-4) Age group, gender, race/ethnicity, educational attainment, employment status, health status, the numeracy skill use at home, the set of 10 plausible literacy skill levels (0-4)	-	-
RQ1	Unconditional binary or proportional odds ordinal logistic regression	The set of 10 plausible numeracy skill levels (0-4)	Age group, gender, race/ethnicity, educational attainment, employment status, health status, the numeracy skill use at home	-
RQ2	Conditional binary logistic regression	8 health information sources including newspaper, magazines, internet, radio, television, books, social network (i.e., family members, friends, or co-workers), and health professionals (1-4: none – a lot)	The set of 10 plausible numeracy skill levels (5-, 3-, & 2-point proficiency levels were explored; see the methods section for more detail)	Age group, gender, race/ethnicity, educational attainment, employment status, health status, the numeracy skill use at home, the set of 10 plausible literacy skill levels (0-4)
RQ3	Conditional binary logistic regression	4 selected preventive health behaviors including flu shot, vision check, screening for osteoporosis and dental visit in the past year (yes vs. no)	The set of 10 plausible numeracy skill levels (5-, 3-, & 2-point proficiency levels were explored; see the methods section for more detail)	Age group, gender, race/ethnicity, educational attainment, employment status, health status, the numeracy skill use at home, the set of 10 plausible literacy skill levels (5-, 3-, & 2-point proficiency levels)

Note: all analyses use the final sampling weight and replicate weights in the PIAAC

Table 1.1: Descriptive Statistics for Socio-Demographic Profile of Numeracy Skills

	Full sample	Numeracy skills Below Level 1	Numeracy skills Level 1	Numeracy skills Level 2	Numeracy skills Level 3	Numeracy skills Level 4 & 5
	N = 3,205	n = 366	n = 736	n = 1,077	n = 777	n = 249
	-	11.21%	21.56%	33.27%	25.78%	8.18%
Variables		Percentages	Percentages	Percentages	Percentages	Percentages
Age group						
Age4549	20.62%	11.09%	21.34%	32.00%	26.24%	9.34%
Age5054	20.96%	10.55%	17.53%	33.44%	27.89%	10.59%
Age5559	19.14%	10.87%	20.48%	32.20%	28.96%	7.49%
Age6065	20.19%	9.24%	20.42%	35.89%	26.97%	7.48%
Age6670	12.19%	12.94%	26.89%	34.21%	19.29%	6.67%
Age71plus	6.90%	17.50%	31.71%	29.91%	17.00%	3.89%
Sex						
Female	52.90%	13.30%	23.08%	35.48%	23.30%	4.84%
Male	47.10%	8.86%	19.84%	30.77%	28.58%	11.96%
Race						
White	73.06%	5.21%	17.62%	35.55%	31.26%	10.35%
Non-White	26.94%	27.49%	32.01%	27.04%	11.05%	2.42%
Education						
College or higher	37.59%	2.68%	9.55%	30.52%	40.85%	16.41%
< College	62.41%	16.31%	28.71%	34.94%	16.78%	3.25%
Employment status						
Employed	77.96%	7.93%	17.44%	33.32%	30.55%	10.76%
Not employed	22.04%	16.97%	28.80%	33.19%	17.41%	3.64%
Self-rated health						
Good or better	77.96%	7.47%	18.97%	34.04%	29.84%	9.69%
Fair or poor	22.04%	24.55%	30.66%	30.49%	11.62%	2.67%
Numeracy skill use at home						
None	11.21%	35.06%	27.53%	29.44%	7.58%	0.39%
Lowest to 20%	21.56%	21.97%	30.68%	34.72%	10.86%	1.86%
21% to 40%	33.27%	12.64%	29.75%	35.68%	18.41%	3.52%
41% to 60%	25.78%	8.72%	21.39%	35.37%	29.14%	5.38%
61% to 80%	7.59%	4.49%	15.58%	35.41%	34.22%	10.30%
> 80%	0.59%	3.06%	12.11%	25.99%	37.26%	21.57%

The percentages are weighted using the sampling and replicate weights
n shows the unweighted sample sizes
For each variable, the sample size may be slightly different as each variable has a different number of missing values.

Table 1.2: Summary of the Significance tests for the Associations with the Numeracy Proficiency levels

Variables	Relationships and Statistical Significance
Age group (1-6)	Negative*
Sex [Female vs. Male (ref)]	Negative*
White (white vs. non-white)	Positive*
Education [College or higher vs. less than college(ref)]	Positive*
Employment status [Employed vs. not employed(ref)]	Positive*
Self-rated health [good health vs. fair/poor health(ref)]	Positive*
Numeracy skill use at home (1-6)	Positive*

Note: * $p < 0.05$; the statistical significance was evaluated using the unconditional binary logistic regression or ordinal logistic regression with the dependent variable: the numeracy proficiency level (0-4: below level 1 – level 4&5)
The estimated coefficient was not reported to avoid a misinterpretation because it was derived from the unconditional model with the plausible values
For the dichotomous variables, “positive” indicates the greater odds of being in the main category (vs. ref or reference group).
For the ordinal variables, “positive” indicates the greater odds of being in the higher categories.

Table 2.1: Descriptive Summary by the Health Information Sources

		Health Professionals				Internet		
Full Sample	None	A Little	Some	A Lot	None	A Little	Some	A Lot
N = 3200	n = 170	n = 368	n = 1,089	n = 1573	n = 767	n = 376	n = 910	n = 1,147
	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages
	5.11%	11.57%	34.68%	48.64%	23.06%	12.22%	29.11%	35.61%
Variables								
Age group								
Age4549	5.44%	15.44%	35.10%	44.03%	16.62%	10.72%	30.84%	41.82%
Age5054	5.90%	12.60%	36.22%	45.27%	17.88%	11.19%	31.75%	39.18%
Age5559	7.42%	11.54%	36.74%	44.30%	24.12%	10.96%	28.03%	36.88%
Age6065	2.73%	9.45%	34.24%	53.59%	23.42%	15.59%	27.48%	33.51%
Age6670	5.07%	7.70%	31.04%	56.19%	29.89%	12.08%	28.26%	29.77%
Age71plus	2.33%	9.99%	30.73%	56.95%	42.76%	13.63%	25.03%	18.58%
Sex								
Female	4.12%	10.86%	34.48%	50.55%	21.49%	10.92%	28.46%	39.13%
Male	6.22%	12.37%	34.92%	46.49%	24.83%	13.68%	29.85%	31.63%
Race								
White	4.39%	11.35%	35.96%	48.30%	19.34%	13.24%	31.70%	35.72%
Non-White	7.11%	12.09%	30.93%	49.86%	33.31%	9.58%	22.05%	35.06%
Education								
College	1.35%	10.40%	36.94%	51.30%	5.52%	11.47%	35.48%	47.52%
< College	7.37%	12.28%	33.36%	46.99%	33.53%	12.68%	25.31%	28.48%
Employment status								
Employed	4.83%	12.44%	37.02%	45.71%	16.61%	12.63%	32.20%	38.57%
Not employed	5.61%	10.03%	30.56%	53.81%	34.47%	11.50%	23.65%	30.38%
Self-rated health								
Good or better	4.60%	12.25%	36.94%	46.20%	16.48%	13.35%	32.21%	37.96%
Fair or poor	6.83%	9.19%	26.49%	57.49%	46.44%	8.26%	18.17%	27.14%
Numeracy skill level								
Below 1	10.52%	11.02%	30.21%	48.52%	60.52%	7.44%	13.40%	18.64%
Level 1	6.28%	10.80%	31.88%	51.04%	37.32%	10.42%	22.82%	29.44%
Level 2	5.47%	10.67%	33.40%	50.45%	20.54%	12.84%	29.37%	37.26%
Level 3	2.87%	12.90%	37.10%	47.13%	6.24%	12.58%	36.70%	44.48%
Level 4& 5	1.69%	13.48%	39.18%	45.66%	0.97%	14.72%	37.33%	46.98%
Numeracy skill use at home								
None	19.55%	12.67%	26.31%	41.48%	70.43%	10.84%	11.30%	7.43%
Lowest to 20%	8.90%	16.34%	29.49%	45.26%	42.80%	13.31%	20.80%	23.09%
21% to 40%	4.90%	11.06%	38.23%	45.81%	26.73%	12.21%	29.89%	31.17%
41% to 60%	3.19%	10.18%	38.09%	48.54%	17.23%	14.78%	31.01%	36.97%
61% to 80%	2.48%	9.49%	35.08%	52.95%	11.76%	12.19%	33.55%	42.51%
> 80%	2.05%	12.17%	34.48%	51.31%	6.05%	8.95%	34.25%	50.75%

The percentages are weighted using the sampling and replicate weights
n shows the unweighted sample sizes
For each variable, the sample size may be slightly different as each variable has a different number of missing values

Table 2.2: Descriptive Summary by the Health Information Sources

				Television				Friends and Family	
	Full Sample	None	A Little	Some	A Lot	None	A Little	Some	A Lot
	N = 3200	n = 323	n = 637	n = 1,239	n = 1001	n = 266	n = 797	n = 1,475	n = 662
		Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages
		10.06%	20.41%	38.79%	30.73%	7.43%	24.55%	46.95%	21.07%
Variables									
Age group									
Age4549	10.66%	20.19%	39.13%	30.02%	5.57%	22.87%	50.63%	20.94%	
Age5054	10.68%	21.46%	37.47%	30.38%	6.14%	25.85%	44.84%	23.17%	
Age5559	9.85%	23.96%	35.43%	30.76%	7.60%	24.71%	45.12%	22.57%	
Age6065	8.36%	19.41%	41.10%	31.14%	5.88%	26.81%	47.23%	20.09%	
Age6670	9.67%	17.09%	43.42%	29.82%	10.83%	24.26%	47.43%	17.47%	
Age71plus	12.76%	16.85%	35.93%	34.46%	15.26%	18.78%	45.76%	20.19%	
Sex									
Female	9.54%	19.26%	39.03%	32.17%	6.65%	23.37%	47.87%	22.11%	
Male	10.65%	21.71%	38.52%	29.12%	8.31%	25.88%	45.91%	19.90%	
Race									
White	11.00%	22.24%	40.64%	26.12%	7.34%	25.05%	47.17%	20.44%	
Non-White	7.52%	15.26%	33.79%	43.42%	7.67%	23.22%	46.67%	22.45%	
Education									
College	12.07%	26.45%	39.40%	22.08%	4.44%	25.02%	50.71%	19.83%	
< College	8.86%	16.80%	38.36%	35.97%	9.23%	24.30%	44.70%	21.78%	
Employment status									
Employed	10.39%	22.29%	40.56%	26.75%	5.74%	23.80%	48.85%	21.61%	
Not employed	9.48%	17.09%	35.58%	37.86%	10.43%	25.91%	43.62%	20.03%	
Self-rated health									
Good or better	9.30%	21.29%	40.86%	28.55%	5.58%	24.22%	49.56%	20.64%	
Fair or poor	12.81%	17.18%	31.65%	38.37%	13.90%	25.72%	37.69%	22.69%	
Numeracy skill level									
Below 1	10.77%	13.86%	27.67%	47.70%	17.71%	20.12%	36.11%	26.05%	
Level 1	9.03%	12.46%	36.62%	41.89%	9.30%	22.41%	45.16%	23.13%	
Level 2	8.87%	18.54%	41.83%	30.75%	7.16%	24.69%	47.70%	20.45%	
Level 3	10.84%	26.94%	41.97%	20.25%	5.92%	28.00%	48.69%	17.39%	
Level 4 & 5	15.21%	34.67%	37.57%	12.55%	3.98%	30.61%	48.51%	16.89%	
Numeracy skill use at home									
None	15.48%	19.05%	32.46%	33.02%	19.02%	20.40%	35.73%	24.85%	
Lowest to 20%	10.18%	17.19%	32.93%	39.70%	10.55%	25.60%	40.40%	23.45%	
21% to 40%	11.50%	17.87%	37.94%	32.69%	8.31%	25.53%	49.23%	16.93%	
41% to 60%	8.55%	16.96%	43.64%	30.86%	4.66%	25.07%	50.04%	20.22%	
61% to 80%	8.72%	23.80%	41.32%	26.16%	6.07%	25.36%	47.11%	21.46%	
> 80%	9.95%	25.45%	37.89%	26.71%	4.30%	22.78%	50.93%	21.99%	

The percentages are weighted using the sampling and replicate weights
n shows the unweighted sample sizes
For each variable, the sample size may be slightly different as each variable has a different number of missing values

Table 2.3: Descriptive Summary by the Health Information Sources

				Books				Newspapers	
	Full Sample	None	A Little	Some	A Lot	None	A Little	Some	A Lot
	N = 3200	n = 606	n = 812	n = 1,282	n = 500	n = 1,015	n = 920	n = 979	n = 286
		Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages
		19.01%	25.96%	39.48%	15.55%	31.54%	28.38%	30.88%	9.21%
Variables									
Age group									
Age4549	22.00%	29.24%	33.86%	14.89%	34.99%	29.44%	26.45%	9.12%	
Age5054	19.91%	26.30%	38.42%	15.38%	30.12%	30.18%	30.43%	9.26%	
Age5559	19.78%	26.41%	38.44%	15.37%	31.26%	28.73%	30.86%	9.15%	
Age6065	12.90%	24.64%	44.52%	17.93%	28.24%	27.62%	34.47%	9.67%	
Age6670	21.33%	24.11%	40.98%	13.58%	35.14%	25.98%	30.96%	7.91%	
Age71plus	19.17%	20.95%	44.94%	14.95%	29.61%	25.10%	34.86%	10.43%	
Sex									
Female	14.51%	22.47%	43.03%	19.99%	30.83%	26.63%	32.35%	10.19%	
Male	24.08%	29.90%	35.48%	10.54%	32.33%	30.36%	29.22%	8.10%	
Race									
White	17.69%	28.31%	39.92%	14.08%	31.16%	30.80%	30.09%	7.95%	
Non-White	22.70%	19.60%	38.12%	19.59%	32.77%	22.08%	32.57%	12.58%	
Education									
College	8.87%	27.08%	45.55%	18.50%	24.21%	31.90%	34.27%	9.62%	
< College	25.06%	25.28%	35.86%	13.79%	35.87%	26.29%	28.87%	8.96%	
Employment status									
Employed	17.16%	26.47%	40.52%	15.85%	28.94%	29.72%	31.66%	9.68%	
Not employed	22.21%	25.08%	37.67%	15.04%	36.08%	26.03%	29.52%	8.36%	
Self-rated health									
Good or better	16.42%	26.61%	41.80%	15.17%	28.30%	29.14%	33.41%	9.15%	
Fair or poor	28.25%	23.79%	31.33%	16.63%	42.78%	25.69%	22.08%	9.44%	
Numeracy skill level									
Below 1	39.09%	16.95%	28.76%	15.20%	42.29%	19.60%	28.13%	9.98%	
Level 1	23.16%	19.83%	39.48%	17.53%	33.89%	23.93%	31.86%	10.31%	
Level 2	15.63%	25.78%	42.45%	17.53%	30.41%	30.41%	30.50%	8.68%	
Level 3	13.05%	29.80%	42.49%	14.65%	28.30%	32.56%	31.17%	7.98%	
Level 4& 5	9.49%	38.54%	40.51%	11.46%	26.11%	37.37%	29.08%	7.44%	
Numeracy skill use at home									
None	59.82%	17.45%	19.85%	2.88%	54.24%	19.42%	17.21%	9.13%	
Lowest to 20%	33.36%	23.70%	30.81%	12.13%	40.92%	27.04%	24.19%	7.86%	
21% to 40%	19.57%	29.52%	36.54%	14.36%	30.11%	28.25%	33.19%	8.46%	
41% to 60%	12.82%	26.67%	47.86%	12.65%	27.62%	31.93%	32.02%	8.42%	
61% to 80%	9.29%	27.48%	43.92%	19.30%	27.99%	26.78%	34.73%	10.50%	
> 80%	10.37%	25.01%	41.63%	22.99%	25.25%	31.38%	33.19%	10.19%	

The percentages are weighted using the sampling and replicate weights
n shows the unweighted sample sizes
For each variable, the sample size may be slightly different as each variable has a different number of missing values

Table 2.4: Descriptive Summary by the Health Information Sources

				Magazines				Radio	
	Full Sample	None	A Little	Some	A Lot	None	A Little	Some	A Lot
	N = 3200	n = 769	n = 933	n = 1,199	n = 299	n = 1,132	n = 888	n = 883	n = 297
		Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages
		23.63%	29.47%	37.76%	9.14%	34.44%	28.58%	27.64%	9.34%
Variables									
Age group									
Age4549	26.60%	30.90%	32.16%	10.34%	29.89%	31.56%	27.13%	11.42%	
Age5054	22.28%	31.15%	37.63%	8.93%	29.31%	32.59%	28.54%	9.56%	
Age5559	21.43%	29.34%	41.29%	7.93%	33.02%	28.39%	29.52%	9.07%	
Age6065	21.75%	27.53%	39.82%	10.90%	36.98%	25.22%	27.88%	9.92%	
Age6670	26.81%	29.95%	37.08%	6.16%	43.08%	25.77%	25.38%	5.77%	
Age71plus	24.89%	25.07%	40.36%	9.68%	45.18%	22.66%	24.38%	7.78%	
Sex									
Female	19.45%	27.34%	41.89%	11.32%	35.91%	29.33%	26.39%	8.37%	
Male	28.34%	31.86%	33.10%	6.70%	32.78%	27.75%	29.04%	10.43%	
Race									
White	22.72%	32.19%	37.51%	7.58%	36.56%	30.06%	25.92%	7.46%	
Non-White	26.09%	22.15%	38.41%	13.35%	28.78%	24.60%	32.10%	14.51%	
Education									
College	13.23%	34.74%	42.14%	9.90%	29.03%	33.55%	29.80%	7.62%	
< College	29.81%	26.33%	35.17%	8.70%	37.73%	25.62%	26.37%	10.28%	
Employment status									
Employed	20.93%	30.34%	38.94%	9.79%	29.91%	30.62%	29.56%	9.91%	
Not employed	28.35%	27.94%	35.70%	8.00%	42.54%	24.99%	24.25%	8.22%	
Self-rated health									
Good or better	19.65%	31.22%	39.68%	9.46%	31.85%	29.70%	29.45%	9.00%	
Fair or poor	37.48%	23.41%	31.03%	8.07%	43.51%	24.68%	21.23%	10.58%	
Numeracy skill level									
Below 1	41.96%	19.71%	28.21%	10.11%	39.12%	21.90%	23.18%	15.80%	
Level 1	29.06%	22.78%	36.59%	11.58%	37.69%	20.31%	30.54%	11.46%	
Level 2	21.75%	29.23%	39.91%	9.12%	35.05%	26.84%	29.66%	8.44%	
Level 3	16.70%	35.26%	39.78%	8.26%	32.92%	35.56%	24.46%	7.07%	
Level 4 & 5	15.61%	42.52%	35.92%	5.95%	32.10%	37.85%	26.23%	3.82%	
Numeracy skill use at home									
None	55.81%	21.27%	14.25%	8.67%	43.45%	21.30%	21.48%	13.77%	
Lowest to 20%	38.59%	27.46%	29.42%	4.54%	40.15%	24.91%	23.61%	11.34%	
21% to 40%	23.76%	28.18%	39.62%	8.44%	36.02%	25.78%	29.59%	8.61%	
41% to 60%	19.31%	31.42%	39.83%	9.45%	35.69%	31.17%	25.30%	7.84%	
61% to 80%	16.10%	30.22%	43.10%	10.58%	33.12%	29.44%	28.68%	8.76%	
> 80%	13.29%	32.43%	42.82%	11.46%	24.85%	33.11%	32.93%	9.11%	

The percentages are weighted using the sampling and replicate weights
n shows the unweighted sample sizes
For each variable, the sample size may be slightly different as each variable has a different number of missing values

Table 2.5: Health Information Source (Health professional): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	1.34 (0.14)*		0.81 (0.24)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			1.19 (0.41)*
Female (vs. Male)			1.28 (0.04)*
White (vs. Non-White)			0.97 (0.41)
College (vs. < College)			1.53 (0.42)*
Employed (vs. Not employed)			1.06 (0.13)
Good or better self-rated health (vs. Fair or poor health)			0.69 (0.12)*
Numeracy skill use at home (1-6)			1.22 (0.24)*
Literacy Level (low vs. medium & high proficiency)		1.79 (0.16)*	1.72 (0.26)*

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of using the health information source – some or a lot
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.6: Health Information Source (Internet): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	3.34 (0.10)*		1.20 (0.18)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.83 (0.04)*
Female (vs. Male)			1.53 (0.11)*
White (vs. Non-White)			0.96 (0.14)
College (vs. < College)			2.27 (0.14)*
Employed (vs. Not employed)			1.26 (0.11)*
Good or better self-rated health (vs. Fair or poor health)			1.58 (0.11)*
Numeracy skill use at home (1-6)			1.49 (0.04)*
Literacy Level (low vs. medium & high proficiency)		4.13 (0.12)*	1.94 (0.18)*

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.7: Health Information Source (Television): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.54 (0.12)*		0.61 (0.19)*
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			1.03 (0.03)
Female (vs. Male)			1.13 (0.09)
White (vs. Non-White)			0.66 (0.14)*
College (vs. < College)			0.58 (0.09)*
Employed (vs. Not employed)			0.85 (0.09)
Good or better self-rated health (vs. Fair or poor health)			1.30 (0.13)*
Numeracy skill use at home (1-6)			1.05 (0.04)
Literacy Level (low vs. medium & high proficiency)		0.68 (0.12)*	1.25 (0.19)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.8: Health Information Source (Family members, friends, or co-workers): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	1.09 (0.11)		0.90 (0.18)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.98 (0.02)
Female (vs. Male)			1.24 (0.10)*
White (vs. Non-White)			0.90 (0.11)
College (vs. < College)			1.06 (0.09)
Employed (vs. Not employed)			1.25 (0.12)
Good or better self-rated health (vs. Fair or poor health)			1.39 (0.10)*
Numeracy skill use at home (1-6)			1.09 (0.03)*
Literacy Level (low vs. medium & high proficiency)		1.16 (0.12)	1.04 (0.19)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.9: Health Information Source (Books): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	1.14 (0.09)		0.71 (0.16)*
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			1.19 (0.03)*
Female (vs. Male)			2.17 (0.09)*
White (vs. Non-White)			0.66 (0.11)*
College (vs. < College)			1.45 (0.09)*
Employed (vs. Not employed)			1.37 (0.10)*
Good or better self-rated health (vs. Fair or poor health)			1.14 (0.11)
Numeracy skill use at home (1-6)			1.35 (0.03)*
Literacy Level (low vs. medium & high proficiency)		1.48 (0.10)*	1.38 (0.17)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.10: Health Information Source (Newspaper): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.85 (0.11)		0.69 (0.17)*
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			1.12 (0.04)*
Female (vs. Male)			1.26 (0.09)*
White (vs. Non-White)			0.71 (0.11)*
College (vs. < College)			1.18 (0.09)
Employed (vs. Not employed)			1.24 (0.08)*
Good or better self-rated health (vs. Fair or poor health)			1.58 (0.11)*
Numeracy skill use at home (1-6)			1.17 (0.03)*
Literacy Level (low vs. medium & high proficiency)		0.98 (0.11)	1.03 (0.18)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.11: Health Information Source (Magazines): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	1.02 (010)		0.70 (15)*
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			1.11 (0.03)*
Female (vs. Male)			1.82 (0.09)*
White (vs. Non-White)			0.64 (0.10)*
College (vs. < College)			1.12 (0.09)
Employed (vs. Not employed)			1.36 (0.09)*
Good or better self-rated health (vs. Fair or poor health)			1.31 (0.12)*
Numeracy skill use at home (1-6)			0.70 (0.15)*
Literacy Level (low vs. medium & high proficiency)		1.30 (0.10)*	1.35 (0.16)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 2.12: Health Information Source (Radio): Estimated Odds Ratios from Binary Logistic Regression Models

	Model 1	Model 2	Model 3
	OR (SE)	OR (SE)	OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.75 (0.11)*		0.71 (0.19)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.99 (0.03)
Female (vs. Male)			0.82 (0.08)*
White (vs. Non-White)			0.61 (0.10)*
College (vs. < College)			1.04 (0.10)
Employed (vs. Not employed)			1.31 (0.09)*
Good or better self-rated health (vs. Fair or poor health)			1.34 (0.13)*
Numeracy skill use at home (1-6)			1.09 (0.03)*
Literacy Level (low vs. medium & high proficiency)		0.78 (0.11)*	0.97 (0.18)

*indicates the statistically significant association with the health information source, $p < 0.05$
The model predicted the probability of being in the main category (i.e., none, a little, and some)
OR = Odds ratio; SE = Standard error
The PIAAC final sampling weights and replicate weights were applied.

Table 3.1: Descriptive Summary by the Preventive Health Behaviors

	Flu Shot		Dental Checkup		Vision Screening		Osteoporosis Screening	
	No n = 1590 Percentages 50.29%	Yes n = 1608 Percentages 49.71%	No n = 1082 Percentages 32.63%	Yes n = 2116 Percentages 67.37%	No n = 1204 Percentages 37.72%	Yes n = 1994 Percentages 62.28%	No n = 1913 Percentages 74.90%	Yes n = 641 Percentages 25.10%
Variables								
Age group		*		*		*		*
Age4549	62.41%	37.59%	30.85%	69.15%	44.21%	55.79%	NA	NA
Age5054	59.12%	40.88%	31.20%	68.80%	40.84%	59.16%	83.06%	16.94%
Age5559	54.85%	45.15%	33.73%	66.27%	42.68%	57.32%	77.67%	22.33%
Age6065	42.25%	57.75%	32.72%	67.28%	33.00%	67.00%	74.17%	25.83%
Age6670	31.90%	68.10%	34.43%	65.57%	30.05%	69.95%	67.08%	32.92%
Age71plus	30.39%	69.61%	36.01%	63.99%	22.27%	77.73%	68.08%	31.92%
Sex		*		*		*		*
Female	47.49%	52.51%	30.41%	69.59%	35.80%	64.20%	64.59%	35.41%
Male	53.45%	46.55%	35.14%	64.86%	39.89%	60.11%	88.12%	11.88%
Race		NS		*		NS		*
White	49.19%	50.81%	30.48%	69.52%	38.56%	61.44%	77.30%	22.70%
Non-White	53.14%	46.86%	38.57%	61.43%	35.82%	64.18%	71.19%	28.81%
Education		*		*		*		*
College	43.71%	56.29%	15.10%	84.90%	30.11%	69.89%	72.80%	27.20%
< College	54.25%	45.75%	43.20%	56.80%	42.30%	57.70%	77.41%	22.59%
Employment status		*		*		NS		*
Employed	53.15%	46.85%	28.61%	71.39%	38.39%	61.61%	79.11%	20.89%
Not employed	45.26%	54.74%	39.83%	60.17%	36.59%	63.41%	70.78%	29.22%
Self-rated health		NS		*		*		*
Good or better	50.75%	49.26%	27.33%	72.67%	36.44%	63.56%	76.89%	23.11%
Fair or poor	48.56%	51.44%	51.46%	48.54%	42.12%	57.88%	72.08%	27.92%
Numeracy skill level		NS		*		NS		*
Low proficiency	51.43%	48.57%	46.96%	53.04%	39.17%	60.83%	72.59%	27.41%
Medium & high proficiency	49.75%	50.25%	25.83%	74.17%	37.04%	62.96%	77.24%	22.76%
Literacy skill level		NS		*		NS		NS
Low proficiency	50.90%	49.10%	47.95%	52.05%	40.01%	59.99%	73.59%	26.41%
Medium & high proficiency	50.14%	49.86%	28.20%	71.80%	37.08%	62.92%	76.39%	23.61%
Numeracy skill use at home		*		*		*		NS
None	63.05%	36.95%	58.67%	41.33%	46.40%	53.60%	74.05%	25.95%
Lowest to 20%	51.49%	48.51%	45.01%	54.99%	47.20%	52.80%	79.99%	20.01%
21% to 40%	49.45%	50.55%	36.69%	63.31%	38.01%	61.99%	76.88%	23.12%
41% to 60%	50.72%	49.28%	30.33%	69.67%	36.46%	63.54%	72.18%	27.82%
61% to 80%	45.18%	54.82%	26.31%	73.69%	36.69%	63.31%	74.32%	25.68%
> 80%	51.32%	48.68%	19.14%	80.86%	28.99%	71.01%	78.09%	21.91%

* indicates the statistically significant associations with the preventive health behavior based on the unconditional binary logistic regression (Wald chi-square test; ($p < 0.05$)

NS indicated not statistically significant association with the preventive health behavior ($p > 0.05$)

n shows the unweighted sample sizes

For each variable, the sample size may be slightly different as each variable has a different number of missing values. The sampling and replicates were applied for all analyses

Table 3.2: Preventive Health Behaviors: Estimated Odds Ratios from Binary Logistic Regression Models of the Flu Shot

Variables	Model 1 OR (SE)	Model 2 OR (SE)	Model 3 OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.94 (0.11)		0.94 (0.16)
Literacy Level (low vs. medium & high proficiency)		1.17 (0.18)	1.17 (0.18)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.73 (0.03)*
Female (vs. Male)			0.76 (0.07)*
White (vs. Non-White)			0.98 (0.13)
College (vs. <College)			0.62 (0.10)*
Employed (vs. Not employed)			0.97 (0.03)
Good or better self-rated health (vs. Fair or poor)			1.16 (0.11)
Numeracy skill use at home (1-6)			0.95 (0.03)

Note: The models predicted the probability of not using the preventive health service
* indicates the statistically significant associations with the preventive health behavior ($p < 0.05$)
OR = Odds ratio [obtained by exp(the estimated regression coefficient)]; SE = Standard error (associated with the estimated regression coefficient)
The PIAAC final sampling weights and replicate weights were applied.

Table 3.3: Preventive Health Behaviors: Estimated Odds Ratios from Binary Logistic Regression Models of the Dental Checkup

Variables	Model 1 OR (SE)	Model 2 OR (SE)	Model 3 OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.39 (0.12)*		0.70 (0.16)*
Literacy Level (low vs. medium & high proficiency)		0.43 (0.12)*	1.03 (0.16)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.98 (0.03)
Female (vs. Male)			0.73 (0.10)*
White (vs. Non-White)			0.98 (0.12)
College (vs. <College)			0.35 (0.12)*
Employed (vs. Not employed)			0.84 (0.13)
Good or better self-rated health (vs. Fair or poor)			0.54 (0.11)*
Numeracy skill use at home (1-5)			0.85 (0.03)*

Note: The models predicted the probability of not using the preventive health service
* indicates the statistically significant associations with the preventive health behavior ($p < 0.05$)
OR = Odds ratio [obtained by exp(the estimated regression coefficient)]; SE = Standard error (associated with the estimated regression coefficient)
The PIAAC final sampling weights and replicate weights were applied.

Table 3.4: Preventive Health Behaviors: Estimated Odds Ratios from Binary Logistic Regression Models of the Vision Checkup

Variables	Model 1 OR (SE)	Model 2 OR (SE)	Model 3 OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.91 (0.11)		1.07 (0.16)
Literacy Level (low vs. medium & high proficiency)		0.88 (0.13)	0.02 (0.17)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.81 (0.03)*
Female (vs. Male)			0.83 (0.08)*
White (vs. Non-White)			0.13 (0.29)*
College (vs. <College)			0.63 (0.10)*
Employed (vs. Not employed)			0.94 (0.09)
Good or better self-rated health (vs. Fair or poor)			0.87 (0.11)
Numeracy skill use at home (1-5)			0.88 (0.03)*

Note: The models predicted the probability of not using the preventive health service
* indicates the statistically significant associations with the preventive health behavior ($p < 0.05$)
OR = Odds ratio [obtained by exp(the estimated regression coefficient)]; SE = Standard error (associated with the estimated regression coefficient)
The PIAAC final sampling weights and replicate weights were applied.

Table 3.5: Preventive Health Behaviors: Estimated Odds Ratios from Binary Logistic Regression Models of the Osteoporosis Checkup

Variables	Model 1 OR (SE)	Model 2 OR (SE)	Model 3 OR (SE)
Numeracy Level (low vs. medium & high proficiency)	0.13 (0.12)*		0.96 (0.21)
Literacy Level (low vs. medium & high proficiency)		1.16 (0.14)	1.08 (0.24)
Age group (45-49, 50-54, 55-59, 60-65, 66-70, 71 plus)			0.77 (0.04)*
Female (vs. Male)			0.238 (0.13)*
White (vs. Non-White)			1.54 (0.15)*
College (vs. <College)			0.67 (0.12)*
Employed (vs. Not employed)			1.07 (0.13)
Good or better self-rated health (vs. Fair or poor)			1.31 (0.11)*
Numeracy skill use at home (1-5)			0.97 (0.04)

Note: The models predicted the probability of not using the preventive health service
* indicates the statistically significant associations with the preventive health behavior ($p < 0.05$)
OR = Odds ratio [obtained by exp(the estimated regression coefficient)]; SE = Standard error (associated with the estimated regression coefficient)
The PIAAC final sampling weights and replicate weights were applied.