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Numeracy, Information Seeking, and Self-Efficacy in Managing Health: An Analysis Using the 2007 Health Information National Trends Survey (HINTS)

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This study examined the unique effects of numeracy on self-efficacy in managing health and on information-seeking experience, and explored the mediating role of information-seeking experience. The proposed model was tested using a national random-digit-dial sample (n = 4,092) of adults participating in the 2007 Health Information National Trends Survey. Findings from multiple regression analyses revealed that higher numeracy was associated with higher self-efficacy in managing health and better (i.e., more positive) health information-seeking experience, and that better information-seeking experience partially mediated the association between higher numeracy and higher self-efficacy. Findings indicated that communication factors (e.g., information seeking) partially mediated the relationship between cognitive abilities (e.g., numeracy) and self-efficacy. Theoretical implications are discussed, along with practical implications for individuals, health care providers, and public health professionals.

Individuals today are exposed to vast amounts of health information, and much of this information contains numbers, statistics, and other numerical concepts. For example, a label on an ibuprofen bottle reads, "Take 1 capsule every 4 to 6 hours while symptoms persist"; an online article about fitness states, "By nixing just 100 calories a day, you'll lose more than 10 pounds a year" (Daly, 2012); an oncologist tells her patient that the 5-year survival rate for stage I breast cancer is 88%. The pervasiveness and intricacy of numerical health information place demands on individuals' health numeracy, the ability to understand and use numbers in a health information context (Bernhardt & Cameron, 2003). Health numeracy is considered an important component of the larger concept of health literacy, broadly defined as the ability to understand and use health information to improve and maintain health (Department of Health and Human Services [DHHS], 2000).

National surveys indicate that a large number of Americans are ill-prepared for the numeracy demands of health information. The 2003 National Assessment of Adult Literacy reports that about 110 million individuals have low numeracy skills, versus about 90 million individuals with low general literacy skills (Kutner, Greenberg, Jin, & Paulsen, 2006). These data suggest Americans' difficulty in their use of numbers may be a more significant problem than the lack of general literacy skills. Despite the sheer number of individuals with low numeracy, the impact of numeracy on health-related outcomes is not well understood (Ciampa, Osborn, Peterson, & Rothman, 2010; Rothman, Montori, Cherrington, & Pignone, 2008).

One of the most important health outcomes associated with numeracy is self-efficacy—a domain-specific cognitive construct referring to an individual's perceived ability to perform a specific behavior (e.g., managing health; Bandura, 1986). Self-efficacy in managing health is likely to serve as an intermediate health outcome in the causal paths from numeracy to distal health outcomes (e.g., health behaviors; Reyna et al. 2009). Another important health outcome associated with numeracy is health information seeking—an active and purposeful behavior to obtain specific health information (Niederdeppe et al., 2007). Health information seeking has been identified as a key pathway through which

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individual characteristics (e.g., health literacy) impact various health outcomes (e.g., self-diagnosis, medical decisions; Anker, Reinhart, & Feeley, 2011). As a large amount of health information is presented in numerical formats, low-numeracy individuals may experience difficulties in seeking health information, and such experiences may in turn impair their self-efficacy in managing health.

Extant studies involving numeracy and self-efficacy mostly focus on patients with a specific disease (e.g., Apter et al., 2009; Cavanaugh et al., 2008; Osborn, Cavanaugh, Wallston, & Rothman, 2010), and the mechanism through which numeracy and information seeking jointly influence self-efficacy has yet to be explored. The present study conducts an analysis of a national sample of adults from the 2007 Health Information National Trends Survey (HINTS). Specifically, the present study has three aims: (1) to examine the unique effects of numeracy on self-efficacy; (2) to examine the unique effects of numeracy on information seeking; and (3) to explore whether information seeking serves as a causal path linking numeracy to self-efficacy.

THEORETICAL FRAMEWORKS

Reyna et al. (2009) recently proposed a causal framework for effects of numeracy on risk comprehension and medical outcomes based on a comprehensive review of empirical reports on numeracy. Their framework indicates that numeracy and health information formatting jointly influence cognition (e.g., perceptions of risk and benefit), which subsequently affects health behaviors and medical outcomes. Two years later, Anker et al. (2011) developed a conceptual framework that highlights the mediating role of health information seeking in the relationship between predisposing characteristics (e.g., health literacy) and related health outcomes. It should be noted that the Reyna et al. (2009) framework neglected to consider self-efficacy and did not specify the mediating role of information seeking, while the Anker et al. (2011) framework did not include cognition (e.g., self-efficacy) as a possible outcome. However, a combination of the Reyna et al. (2009) and Anker et al. (2011) frameworks suggests that a possible causal path from numeracy to self-efficacy is through information seeking. Empirical research for this possible causal path model is reviewed next.

Numeracy and Self-Efficacy

Numeracy is considered one of six major literacy skills, along with listening, speaking, reading, writing, and cultural knowledge (Institute of Medicine, 2004). At the rudimentary level, numeracy involves identifying numbers and performing simple arithmetic calculations; at a higher level, numeracy involves logical reasoning and an understanding of probabilities and statistics (Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005; Reyna et al., 2009). Examining the unique contribution of numeracy is warranted, as numeracy is believed to be a separate faculty, based on studies controlling for education, intelligence, literacy, and other factors (Reyna et al., 2009).

Due to a shift from a provider-centered to a patient-centered model, there is an emphasis on the active participation of individuals in their health care (Apter et al., 2008). As a result, it is becoming increasingly important to understand the possible impact of the numeracy deficit on individuals' self-efficacy in managing health. Studies have indicated that numerate skills specific to a health-related task were related to self-efficacy in performing that task. For instance, Osborn et al. (2010) reported that numeracy emerged as a stronger predictor of self-efficacy for diabetes self-management than general health literacy. In addition, the Apter et al. (2009) study suggested that lower numeracy was associated with lower self-efficacy in asthma management. In terms of the association between numeracy and self-efficacy in managing overall health, one study (Manganello & Clayman, 2011) indicated that in a sample of young adults, respondents with lower numeracy were more likely to have lower self-efficacy in managing overall health. The findings to date indicate further research is needed to better understand the relationship between numeracy and self-efficacy in managing overall health in a general sample of adults. As such, the following hypothesis is posed:

H1: Higher numeracy is associated with higher self-efficacy in managing overall health.

Numeracy and Information Seeking

Information seeking is a goal-oriented activity that involves critically evaluating the utility and credibility of each piece of information (Anker et al., 2011; Metzger, 2007). Information seeking is a complex process that demands cognitive abilities, such as logical reasoning, which represents an advanced level of numeracy in contrast to the rudimentary level of numeracy (e.g., number identification, arithmetic calculation; Marchionini, 1995; Reyna et al, 2009). Also, with the rapid development and emerging findings of modern health and medical sciences, health information is increasingly presented in numerical formats. Navigating an environment filled with numerical concepts can be especially challenging for low-numeracy individuals who are in need of health information. Thus, it is possible that low numeracy becomes a barrier for successful health information seeking.

Health information seeking has been operationalized in a number of ways, such as content of health information seeking, frequency of health information seeking, or general experience of health information seeking (Anker et al., 2011). For three reasons, the present study operationalizes health information seeking as individuals' general information-seeking experience. First, information-seeking experience reflects overall information-seeking behavior

across multiple information channels; second, information-seeking experience indicates how well individuals are able to navigate the information environment, as such experiences provide a self-rating of the process and outcome of the information-seeking efforts (Arora et al., 2007); third, improving the public's information-seeking experience has been recommended as an important strategy for promoting public health (Beckjord, Finney Rutten, Arora, Moser, & Hesse, 2008).

Previous studies addressing the impact of numeracy on health information-seeking experience typically have been limited to communication with health care providers. Findings from these studies indicated that individuals with lower numeracy were more likely to experience poor interactions with their health care providers (e.g., Ciampa et al., 2010; Smith, Wolf, & von Wagner, 2010). The present study extends the line of research on patient–provider communication and speculates that low-numeracy individuals may also experience difficulties when they seek health information from other information channels besides health care providers. As such, the following hypothesis is advanced:

H2: Higher numeracy is associated with more positive information-seeking experience.

Information-Seeking Experience Mediates the Link Between Numeracy and Self-Efficacy

In addition to numeracy, health information-seeking experience may be another predictor of self-efficacy in managing health. There are four sources central for the development of self-efficacy: mastery experience, social modeling, physiological states, and verbal persuasion; mastery experience—individuals' personal experience with success or failure—has been identified as the most important source to improve self-efficacy (Bandura, 1997). More specifically, if one has performed a task successfully in the past, this positive experience is likely to enhance one's self-efficacy. The present study speculates that individuals' positive experience in health information seeking may make them feel more capable of managing their health.

Studies examining health literacy, information seeking, and self-efficacy at the same time indicate that these three constructs are significantly correlated. For example, von Wagner, Semmler, Good, and Wardle (2009) found that limited health literacy had a direct negative impact on both information seeking/processing and self-efficacy for participating in colorectal cancer screening. Ussher, Ibrahim, Reid, Shaw, and Rowlands (2010) suggested that difficulty in understanding health information, such as appropriate types and intensities of physical activity and safety issues, may lead individuals with lower health literacy to feel less confident about exercise (i.e., lower self-efficacy for exercise). In sum, the findings to date indicate that lower health literacy leads to difficulty in seeking or understanding health information, and such difficulty impairs self-efficacy for specific health behaviors. However, there is a lack of understanding of the causal mechanism that explains how numeracy affects self-efficacy in managing health. The current study represents a first attempt to explore the possible mediating role of information seeking between numeracy and self-efficacy in managing health. The following research question is posed:

RQ: Does more positive information-seeking experience mediate the association between higher numeracy and higher self-efficacy?

A hypothesized conceptual model illustrating the relationships among the three major constructs is shown in Figure 1.

METHOD

The current investigation relies upon the 2007 Health Information National Trends Survey (HINTS), a nationally representative survey designed to investigate the American public's need for, access to, and use of health and cancer information (National Cancer Institute [NCI], 2009; visit http://hints.cancer.gov). The 2007 HINTS was chosen because it is the first large national survey in the United States that incorporates the measurement of numeracy in the health context. This survey relied on two modes (random digit dial [RDD] and mail) to gauge responses, and the overall response rate was 24.2% ($n = 4{,}092$) for the RDD sample and 31.0% ($n = 3{,}582$) for the mail sample. Despite the higher response rate of the mail sample, it was subjected to significantly higher nonresponse bias than the RDD sample (Peytchev, Ridenhour, & Krotki, 2010). Thus, the current analysis only included data of the RDD sample, which produced a representative sample of telephone households in the United States.

Participants

The ages of participants who completed the 2007 HINTS in the RDD mode ranged from 18 to 97 years ($M = 56.02$, $SD = 17.02$) and 1,584 (38.8%) were male. A majority of participants were White (87.7%). Participants' education

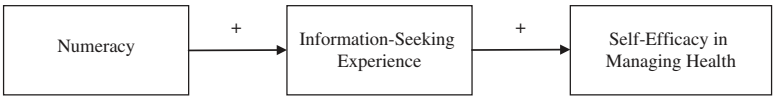

FIGURE 1 Hypothesized conceptual model presenting relationships between constructs.

consisted of less than high school (9.8%), high school graduate (26.2%), some college (27.9%), bachelor's degree (23.8%), and post-baccalaureate degree (12.3%). Seventeen percent of participants had annual incomes less than $20,000. Fifty-nine percent of participants were married or living as married. Participants' self-reported health status ranged from 1 = *excellent* to 5 = *poor*, with a mean of 3.43 (*SD* = 1.00), indicating that their average health status was good.

Measures

Numeracy. The 2007 HINTS included three items designed to measure numeracy: (1) "In general, how easy or hard do you find it to understand medical statistics?" (2) "In general, I feel uncomfortable with health information that has a lot of numbers and statistics." (3) "In general, I depend on numbers and statistics to help me make decisions about my health." The responses for the first item ranged from 1 = *very easy* to 4 = *very hard*. The responses for the second and third items ranged from 1 = *strongly agree* to 4 = *strongly disagree*. Items were recoded so that higher values indicate greater numeracy. These items failed to reliably load onto a single dimension (α = .46), and removal of any one item failed to improve internal consistency.

The current study used the first item as the measure for numeracy for two reasons. First, understanding medical statistics represents an advanced level of numeracy (Reyna et al., 2009) in health/medical contexts; individuals with advanced numeracy should also possess rudimentary numeracy. Thus, the first item provides greatest face validity and best conceptualizes numeracy in health/medical contexts among the three items. Second, the first item was taken from the three-item STAT-confidence scale, which was developed by Woloshin, Schwartz, and Welch (2005), and was demonstrated to have good reliability and usability.[1]

Information-seeking experience. Questions about information-seeking experience took the general format: "Based on the results of your most recent search for information about health or medical topics, how much do you agree or disagree with the following statements?" Four items following this question assessed information-seeking experience: "It took a lot of effort to get the information you needed," "You felt frustrated during your search for the information," "You were concerned about the quality of the information," and "The information you found was hard to understand." These four items were taken from the six-item Information Seeking Experience (ISEE) scale, which was developed by Arora et al. (2007), and was found to have good reliability (Arora et al., 2007; Beckjord et al., 2008).[2] The responses for these items ranged from 1 = *strongly agree* to 4 = *strongly disagree*. Higher values indicate more positive information-seeking experience. The reliability was α = .77 for this measure.[3]

Self-efficacy in managing health. Self-efficacy in managing health was assessed by one item asking participants to rate, "Overall, how confident are you about your ability to take good care of your health? Would you say . . . " This measure was developed by the HINTS team at NCI (2007) specifically for the 2007 HINTS.[4] The responses ranged from 1 = *completely confident* to 5 = *not confident at all*. Items were recoded so that higher values indicate higher self-efficacy for taking care of one's own health.

Control variables. Demographics (age, gender, race, education, income, and marital status) and self-reported health status were included as control variables.

Analysis Plan

All analyses were conducted using STATA SE Version 11 (StataCorp, College Station, TX), a statistical program that can incorporate replicate weights for inferential statistics.[5] Survey commands were used to incorporate the RDD sampling weights and replicate weights to perform a jackknife estimation of variance for inferential statistics. An examination of histogram reports of dispersion suggested all study variables except dichotomous variables achieved (or were close to) normal distribution, an assumption for conducting

[1]The STAT-confidence scale contains three items: (1) In general, how easy or hard do you find it to understand medical statistics?; (2) I am confident that I can make sense of medical statistics; and (3) I feel like I do not know how to interpret medical statistics (Woloshin et al., 2005). The responses for the first item ranged from 1 = *very easy* to 4 = *very hard*. The responses for the second and third items ranged from 0 = *strongly disagree* to 4 = *strongly agree*.

[2]The ISEE scale (Arora et al., 2007) has another two items that were not implemented in the 2007 HINTS and thus were not included in the present study. These two items are as follows: You wanted more information but did not know where to find it. You did not have the time to get all the information you needed.

[3]The 2007 HINTS also has a single-item measurement about confidence in getting health information. We consider that this single item should be included in the measure for the information-seeking construct in our model, because this single item is highly correlated with the four items that we used for the information-seeking construct. However, the reliability for the information-seeking construct did not improve (i.e., remained .77), when this single item and the four items that we used were combined into a scale. Thus, we decided to remove this single item from the measure for information seeking.

[4]The item's stem "Overall, how confident are you about your ability . . . ," is a standard approach to assessing self-efficacy, and the context "to take good care of your health" was added, so the whole item became a measure for self-efficacy in managing health (N. K. Arora, personal communication, February 4, 2013).

[5]At this stage, SPSS does not have the ability to incorporate replicate weights for inferential statistics (National Cancer Institute [NCI], 2009). If the replicate weights are not incorporated in the analysis, the standard errors of coefficients will probably be underestimated; therefore, the *p* values will be smaller than they "ought to" be, and a type I error is more likely to occur (NCI, 2009). That is why the present study used STATA rather than SPSS for data analysis.

TABLE 1
Descriptive Statistics and Zero-Order Correlation Matrix of Study Variables (Based on the Unweighted Sample)

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Age	—	.034*	.118**	−.081**	−.201**	−.098**	−0.03	−.078**	−.048*	.054**
2. Gender		—	−.005	−.059**	−.143**	−.145**	−.017	−.053**	.007	.027
3. Race			—	.105**	.129**	.095**	.099**	.034*	.110**	.023
4. Education				—	.487**	.138**	.236**	.243**	.184**	.110**
5. Income					—	.454**	.300**	.185**	.202**	.141**
6. Marital status						—	.128**	.051**	.054**	.013
7. Health status							—	.129**	.172**	.350**
8. Numeracy								—	.266**	.186**
9. Information seeking									—	.191**
10. Self-efficacy										—
Mean	56.02	1.61	0.88	3.03	5.42	0.59	3.43	2.65	2.94	3.92
SD	17.02	0.49	0.33	1.18	2.12	0.49	1.00	0.81	0.76	0.82

*$p < .05$. **$p < .01$.

multiple regressions (Cohen, Cohen, West, & Aiken, 2003). Two hierarchical multiple regressions were run to test the hypothesized model.

It should be noted that previous studies examining numeracy with the 2007 HINTS all treated numeracy and outcome variables (e.g., patient–provider communication) as dichotomous variables in their analyses (Ciampa et al., 2010; Manganello & Clayman, 2011; Smith et al., 2010). Dichotomizing variables is a practice that potentially discards information and, as a consequence, often leads to a decrease in variance accounted for in the outcome variable and a reduction in statistical power (Cohen, 1983, 1990). For example, in the Ciampa et al. (2010) study, the original numeracy variable had four categories (very hard, hard, easy, and very easy) in terms of the difficulty level in understanding medical statistics. These authors dichotomized the numeracy variable into high and low numeracy by combining "very hard" and "hard" into the low numeracy category, and combining "easy" and "very easy" into the high numeracy category. As a result, their regression analyses could only show the difference in the outcome variables (e.g., quality of communication with providers) between two groups of people (i.e., high vs. low numeracy), although in reality their data had potential to reveal richer information. In contrast, the present study retains the original scaling information of all variables and, in each regression analysis, uses all the information contained in the data to model the closest fitting linear relationship between the predictors and the outcome variable. Thus, the current regression analyses will be able to show the predicted magnitude of change in the outcome variables (e.g., self-efficacy) per unit change in numeracy.

RESULTS

Table 1 provides descriptive statistics and a zero-order correlation matrix of study variables based on the unweighted sample.[6] Results of the two hierarchical regressions are provided in Tables 2 and 3. As the statistical program (STATA SE Version 11) used in the present study can only report unstandardized regression coefficients under the survey command for linear regression (svy: regress), β_i (the standardized regression coefficient of each predictor in each regression equation in Tables 2 and 3) was calculated by the following formula prescribed by Cohen et al. (2003),

$$\beta_i = B_i \cdot sd_i / sd_Y$$

where B_i is the unstandardized regression coefficient of each predictor, sd_i is the standard deviation of each predictor, and sd_Y is the standard deviation of the dependent variable, in each regression equation presented in Tables 2 and 3.[7]

The hypothesized model was tested by examining the four criteria of the analytical framework for mediation (Baron & Kenny, 1986). Model 2 of Table 2 found a positive relationship between numeracy (the predictor) and self-efficacy (the outcome variable), when information seeking (the mediator) had not been entered into the regression model ($\beta = .154$, $p < .01$); therefore, the first criterion for mediation was met. Model 2 of Table 3 found that numeracy had a positive association with information seeking ($\beta = .237$, $p < .01$); thus, the second criterion for mediation was satisfied. Model 3 of Table 2 found that, after controlling for numeracy, information seeking showed a positive association with self-efficacy ($\beta = .069$, $p < .05$); thus, the third criterion for mediation

[6]Interested readers can access the response frequencies for the items of the main measures on the HINTS Website (http://hints.cancer.gov). For example, here is the link for the response frequency for the item "In general, how easy or hard do you find it to understand medical statistics": http://hints.cancer.gov/question-details.aspx?dataset=2007&qid=785&qdid=2372&method=Combined

[7]Interested readers can contact the corresponding author for the standard deviations (based on the weighted sample) of all variables in each regression equation of Tables 2 and 3.

TABLE 2
Hierarchical Regression of Predictors on Self-Efficacy (Based on the Weighted Sample)

	Criterion Factor = Self-Efficacy								
	Model 1			*Model 2*			*Model 3*		
Predictor	*B*	*SE(B)*	β	*B*	*SE(B)*	β	*B*	*SE(B)*	β
Age	.002	.001	.040	.002	.001	.051	.003	.002	.052
Gender	.055	.034	.033	.072	.035	.044*	.094	.040	.058*
Race	−.103	.062	−.051	−.109	.059	−.054	.003	.083	.001
Education	−.003	.018	−.004	−.020	.018	−.027	.003	.018	.004
Income	.034	.012	.085**	.025	.012	.063*	.009	.015	.022
Marital status	−.094	.036	−.056*	−.074	.038	−.044	−.064	.050	−.038
Health status	.309	.020	.370**	.302	.021	.361**	.321	.027	.383**
Numeracy				.159	.025	**.154****	.144	.028	**.139****
Information seeking							.069	.033	**.069***
Change of adjusted R^2			.15**			.02**			.04**
Total adjusted R^2			.15**			.17**			.21**

Note. B = unstandardized regression coefficient; SE = jackknife standard error; β = standardized regression coefficient.
*$p < .05$. **$p < .01$.

TABLE 3
Hierarchical Regression of Predictors on Information Seeking (Based on the Weighted Sample)

	Criterion Factor = Information Seeking					
	Model 1			*Model 2*		
Predictor	*B*	*SE(B)*	β	*B*	*SE(B)*	β
Age	−.003	.001	−.063*	−.002	.001	−.049
Gender	.039	.052	.025	.052	.047	.034
Race	.211	.086	.102*	.197	.080	.096*
Education	.049	.026	.068	.028	.024	.039
Income	.050	.014	.127**	.036	.014	.092*
Marital status	−.043	.057	−.027	−.002	.057	−.001
Health status	.111	.028	.139**	.094	.029	.118**
Numeracy				.234	.027	**.237****
Change of adjusted R^2			.08**			.05**
Total adjusted R^2			.08**			.13**

Note. B = unstandardized regression coefficient; SE = jackknife standard error; β = standardized regression coefficient.
*$p < .05$. * $p < .01$.

was met. Model 3 of Table 2 also found that, after controlling for information seeking, the previously positive and significant relationship between numeracy and self-efficacy (β = .154, $p < .01$) was reduced in magnitude but still statistically significant (β = .l39, $p < .01$). The Sobel test indicated that this reduction in magnitude was statistically significant (z = 2.14, $p < .05$; Preacher & Leonardelli, 2001).

These findings suggested the four criteria for mediation were all satisfied, and there was a partial mediation between numeracy and self-efficacy through information seeking. Therefore, H1 and H2 were both supported and RQ was answered. Figure 2 displays the regression coefficients between each construct. The size of the direct effect from numeracy to self-efficacy was .139 and the size of the indirect effect was .016. The hypothesized conceptual model explained 21% of the variance in self-efficacy in managing health. Numeracy and information seeking together explained 6% of the variance in self-efficacy, above and beyond what was explained by demographics and self-reported health status.

DISCUSSION

This study examined the unique effects of numeracy on self-efficacy in managing health and on information-seeking experience, and explored the mediating role of information-seeking experience using the 2007 HINTS. Findings revealed that higher numeracy was associated with higher self-efficacy in managing health and better (i.e., more positive) health information-seeking experience, and that better information-seeking experience partially mediated the association between higher numeracy and higher self-efficacy. It should be noted that positive health information-seeking

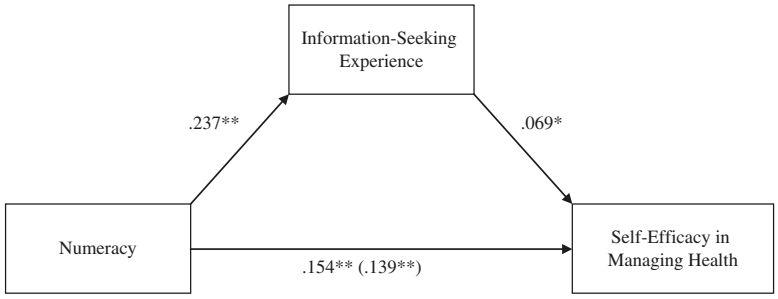

FIGURE 2 Regression coefficients between constructs, based on the mediational analysis. The number inside the parentheses is the regression coefficient after information-seeking experience (the proposed mediator) was entered into the model; significance: $^{*}p < .05$. $^{**}p < .01$.

experience in the present study indicates one's recent search for health information was self-rated as a success in terms of the process and outcome (Arora et al., 2007). Specifically, a positive/successful experience means the process of health information seeking was perceived as easy and smooth, and the outcome of information-seeking efforts was considered fruitful (i.e., the obtained information satisfied the needs of information seekers). The implications of these findings are discussed in the following.

The finding that numeracy had a direct positive association with self-efficacy in managing health is important for two reasons. First, this finding justifies that numeracy is an important factor that merits consideration in future studies of determinants of self-efficacy for health behaviors. Bandura (1997) identified four essential sources for the improvement of self-efficacy. Enhancing numeracy could also be a means of increasing self-efficacy for health behaviors, as revealed by the present findings. As much information in health and medical settings is heavily numerical, a better understanding of such numerical health information (i.e., higher health numeracy) may provide individuals knowledge regarding health management, and may boost their self-perceived ability in managing health. Second, the positive association between numeracy and self-efficacy in managing overall health indicates that the effects of numeracy on self-efficacy for health behaviors may be generalizable across different health contexts. Studies examining the effects of numeracy on self-efficacy have focused on self-efficacy in performing a specific health behavior, such as asthma management (e.g., Apter et al., 2009) or diabetes control (e.g., Cavanaugh et al., 2008). Findings from the present study indicate that the impact of numeracy on self-efficacy is probably salient, not only in the management of specific diseases, but also in terms of overall health management.

The finding that higher numeracy was associated with more positive information seeking is in line with Manganello and Clayman's (2011) study, which reported a similar association in a sample of young adults. Other studies have generally supported that higher self-perceived numeracy was associated with more positive patient–provider interactions (e.g., Ciampa et al., 2010; Smith et al., 2010). It should be noted that health care providers may not be the only source of health information when individuals have such needs. Family members, friends, and mass media are also viable sources of health information. The present study examined general health information-seeking experience, representing usage across multiple channels, and tested the theoretical chain from numeracy to information seeking based upon previous studies on patient–provider communication (e.g., Ciampa et al., 2010; Smith et al., 2010). The consistency of the current findings with Manganello and Clayman's (2011) confirms that low numeracy may impair individuals' usage of many different communication channels for health information seeking, and that the detrimental effect of low numeracy on health information seeking may be a general problem for the American population, regardless of age differences.

The present study also provides evidence that individuals with higher numeracy are more likely to have positive experiences in seeking health information, and such positive experiences may in turn enhance their self-efficacy in taking care of their own health. Bandura (1997) suggested that individuals' self-efficacy in performing a behavior is most likely to be improved through previous successful experiences in performing that behavior. Findings from the present study indicate that positive experiences related to health management (e.g., seeking out health information) may enhance self-efficacy as well. Positive experiences in seeking health information are important, as such experiences are more likely to produce quality health information, which can provide direct guidance on how to take care of one's own health and potentially reduce uncertainty and anxiety regarding a health concern. Positive experiences in seeking health information may strengthen information seekers' belief that, when needed, quality health information is available, accessible, and comprehensible. Also, information-seeking behavior can be thought of as seeking out informational support, based on the perspective of social support—supportive behavior performed for an individual by others (Burleson & MacGeorge, 2002). Through positive experiences in seeking health information, received informational support may directly benefit the information seekers, while the perceived availability of informational support can buffer the stress caused by a health problem.

The finding that positive information-seeking experience serves as a partial mediator linking higher numeracy and higher self-efficacy is not directly comparable with previous studies (e.g., Donovan-Kicken et al., 2012) due to differences in study contexts and measures of key variables. An alternative model, which assumes that self-efficacy mediates the association between numeracy and information seeking, is conceptually possible, although this model was not supported by the present data. It is probable that individuals with higher subjective health numeracy tend to have more confidence in managing their health (i.e., higher health self-efficacy). These individuals may be more open to new information and more active in seeking/using health information, and thus may be more likely to have positive experiences in such efforts. On the other hand, individuals with higher health self-efficacy may be able to minimize worry and distress associated with health concerns, and the decreased negative affect may improve experiences in seeking health information, as suggested by the Risk Perception Attitude Framework (Rimal & Real, 2003) and a study on information processing and negative affect (Beckjord et al., 2008).

Two theoretical implications are apparent from the current findings. First, numerous studies have documented that self-efficacy largely determines the performance of many health behaviors (e.g., Bricker et al., 2010; White, Wójcicki, & McAuley, 2012); however, the possible antecedents of self-efficacy have received less attention. The present study contributes to the literature by identifying numeracy and information seeking as potential causal determinants of self-efficacy among a national sample of adults. Second, although the Reyna et al. (2009) framework identifies numeracy as a causal factor for various proximal and distal health outcomes, and although the Anker et al. (2011) framework highlights information seeking as a mediating factor linking health literacy and relevant health outcomes, the possible causal mechanisms by which numeracy and information seeking influence health outcomes have not been fully explored. Indeed, as Reyna et al. (2009) pointed out, research on health numeracy has been uninformed by theories and mostly descriptive, without addressing causal mechanisms. The current study fills this gap by proposing and testing a conceptual model based on a combination of these two existing frameworks.

Findings from this study are potentially applicable to individuals, health care providers, and public health professionals. The current model suggests that a feasible strategy to boost self-efficacy lies in an improvement of numeracy and information-seeking skills, and this can provide guidance to individuals trying to increase their self-efficacy. Specifically, individuals should realize that being health numerate is a personal asset (Nutbeam, 2008), and that understanding numerical health information and knowing where and how to obtain quality health information are strategies to empower themselves to access health care and to make informed health-management decisions (Reyna et al., 2009; Smith et al., 2010). Individuals need to assume a certain level of personal responsibility in improving their numerate and information-seeking skills, if resources for such advancement are provided for and are accessible to them. The emphasis on personal responsibility in health care (Minkler, 1999) is in line with the current trend of patient-centered approach and has the potential to reduce the public health burden caused by poor numerate and information-seeking skills.

Results from this study are also informative for health care providers in terms of interaction with patients. The single-item measurement for numeracy in this study takes little time to administer, and can allow health care providers to quickly identify patients with low numeracy. A single item, "How confident are you filling out medical forms by yourself?," has been used to detect low health literacy in some clinical populations, and its validity has been demonstrated (Chew et al., 2008). Initiative in clinic settings should be developed to address the needs of not only low-literacy patients, but low-numeracy ones as well. Health care providers should be aware of the numeracy levels of their patients, and accordingly adjust their conversation styles or even adopt visual aids (e.g., pictures, diagrams, and photographs) to ensure the comprehension and usage of numerical health information by their patients (Portnoy, Roter & Erby, 2010).

Findings from this study are important considerations for public health professionals as well. It should be noted that promoting individual and public health is not only a personal responsibility, but also a social responsibility (Minkler, 1999). Public health professionals may want to incorporate components designed to improve numeracy in health settings into their health education or intervention programs. They may also consider offering training on searching health information at no cost to individuals who lack such skills.

On the other hand, special efforts should be employed to effectively deliver numerical health information to the public. One possible way is to reduce the numeracy demands of health information, making the information as explicit as possible, without the need for readers to perform calculations or logical reasoning (Peters, Hibbard, Slovic, & Dieckmann, 2007). Reducing the numeracy demands of health information is likely to benefit both lower and higher numeracy individuals. Another possibility is to add visual aids to accompany numerical health information (Joram et al., 2012). Visual aids may facilitate the understanding and retention of numerical information. A third option is using real-life examples or vivid analogies, and thus making numerical health information more relevant and comprehensible to the target population. In addition to tailoring numerical information, various communication channels (e.g., print media, radio, TV, and the Internet) can be employed to reach individuals who have difficulty in seeking out health information.

Two methodological strengths of this study are worth mentioning. One strength is that, unlike previous studies (Ciampa et al., 2010; Manganello & Clayman, 2011; Smith et al., 2010) that dichotomized numeracy and outcome variables in their analyses, the current study used the original scaling information of all major constructs and treated them as continuous variables in the data analysis, revealing richer information from the original data and enhancing the statistical power of the findings. As Cohen (1983) pointed out, "Since methods are available for making use of all the original scaling information" (p. 249), dichotomizing variables is just a convenient practice that is "neither appropriate nor justifiable" (p. 252). It is the goal of the present study to call attention to the field of health communication to refrain from using the dichotomization processing of data. A second strength is that the current model was relatively simple and explained a moderate amount of variance (21%) in the outcome variable. Cohen (1990), in his reflection about the application of statistics, remarked that he had seen too many studies with a large number of outcome variables, with way too many predictors, or both. The current study affirms Cohen's (1990) principle that "less is more (fewer variables and more highly targeted issues [make for better studies])" (p. 1304), arguing that simplicity of model is better practice.

Several limitations of this study should be noted. First, this study relied on a secondary data analysis of the 2007 HINTS, and this survey failed to collect data related to the abilities of reading, writing, speaking, and listening, which are also named health literacy components. Some empirical studies (e.g., Osborn et al., 2010) have found that when numeracy and general health literacy were considered in combination, only numeracy was a significant predictor of self-efficacy, while health literacy was not; however, it is possible that other health literacy components may serve as confounders in the relationship between numeracy and self-efficacy. Thus, controlling other literacy components in the regression analysis may present a clearer view of the unique impact of numeracy on self-efficacy.

Second, due to the constraints of the 2007 HINTS, numeracy and self-efficacy in managing health in the present study are both single-item measures. Single-item measures may incur more measurement error, despite their advantage in easy implementation, especially for population-based surveys. Also, there are greatly varied measures for health numeracy (though they are commonly uninformed by theory; Reyna et al., 2009), health information seeking (Anker et al., 2011), and health self-efficacy (e.g., Smith, Wallston, & Smith, 1995). Findings from the current study may differ according to the measures used. For example, the eight-item scale assessing self-efficacy in managing general health (Smith et al., 1995) has been widely used. This eight-item scale may better reflect the conceptual definition of self-efficacy, and capture the totality of the self-efficacy construct, than the single-item measure in the current study. Additionally, health information seeking could be measured as information-seeking behaviors with information sources categorized; thus, it will be possible to compare the importance of different sources (e.g., health care providers vs. the Internet).

Third, although information seeking was found to partially mediate the relationship between numeracy and self-efficacy in managing health, other factors (e.g., health knowledge, past experience of managing health) may also serve as potential mediators in this relationship. The causal relationships among numeracy, information seeking, and self-efficacy in managing health are presumed and should be interpreted with caution as well, due to the cross-sectional nature of this study.

In conclusion, health intervention programs targeting only self-efficacy are unlikely to reduce the health divide related to health literacy/numeracy (Berkman, 2004; DeWalt, Boone, & Pignone, 2007). The current study contributes to the numeracy and information-seeking literature by highlighting the potential negative impact of low numeracy on self-efficacy and justifying the partial mediating role of information seeking. Additionally, this study evinces that the effects of cognitive abilities (e.g., numeracy) on self-efficacy were partially mediated by communication factors (e.g., information seeking). Future research should examine other literacy components in addition to numeracy, develop and validate theory-based health numeracy scales, investigate health information seeking with information sources categorized, and explore other potential mediators when examining the relationships among numeracy, information seeking, and self-efficacy. The exploration of which formats are optimal and which communication channels are most effective in delivering numerical health information is another potential research direction that may inform strategies for health intervention designs and implementations.

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