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The Relationship of Health Numeracy to Cancer Screening

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Abstract

Background—Health numeracy is associated with increased understanding of cancer risk reduction information and improved control of chronic disease.

Methods—A cross-sectional survey was conducted among a primary care population to evaluate the effect of health numeracy on breast, cervical, and colorectal cancer screening.

Results—No association was found between health numeracy and cancer screening. However, at a baseline screening rate of 85%, increased knowledge (RR 1.06, 95% CI 1.02–1.08) and decreased perceived barriers (RR 0.93, 95% CI 0.92–0.95) were associated with increased screening rates.

Conclusions—Health numeracy was not predictive of cancer screening among a primary care population.

Introduction

The decision of patients to undergo cancer screening per recommended guidelines remains complex in the context in primary care practice. Enthusiasm for cancer screening in the public appears high (1), and physician-based strategies, in particular, have been effective in improving screening rates (2). However, as overall target goals for screening tests have been met in some groups, inequities persist for several groups including those of lower income, lower levels of education, recent immigrants, those without health insurance or a usual source of care, and by race/ethnicity (3). One factor that may mediate the relationship between socioeconomic status and cancer screening is health literacy (4–13). Although health literacy has been associated with improved knowledge of cancer screening (4–7), studies of the association of health literacy with cancer screening behaviors demonstrated mixed results (8–13).

The health literacy construct encompasses several domains including that of health numeracy (14). Health numeracy can be defined as the ability to use and understand numeric and probability based information in the context of health care. There are several reasons to posit that an understanding of numeric concepts in particular will encourage cancer screening decisions supported by guidelines. First, cancer screening is recommended at a given interval; scheduling tests at appropriate dates requires an understanding of dates and time. Second, recommendations for cancer screening tests are often based upon data from randomized clinical trials. Numerate persons may better understand and trust efficacy information related to clinical studies of cancer screening interventions. Indeed, numeracy has been found to influence both critical thinking and affective responses in decision making involving risks and benefits (15, 16). The objective of this study is to evaluate the relationship of health numeracy to cancer screening behavior in a primary care population.

Materials and Methods

We conducted a cross-sectional survey from 10/2005 through 3/2007 with data analysis completed in 2009. Participants were recruited from enrollees in one of three internal medicine primary care clinics associated with an academic medical center. Inclusion criteria were age 40–74 and the ability to speak English. Exclusion criteria included cognitive impairment as measured by a Folstein Mini Mental State score of < 23, a personal history of breast, cervical, colorectal or prostate cancer, or failure to pass a vision test (17). A random sample of enrollees was sent a recruitment letter and stamped response postcards. The participants came in for one study visit to respond to the survey (Appendix). Prior to the survey, participants completed a vision test, the Folstein Mini Mental State exam and the Rapid Evaluation of Adult Literacy in Medicine (REALM) reading health literacy test (18). Those with less than a 9th grade reading level were offered the option of having the survey read to them. The survey was administered in a private room with a research assistant available to answer questions. Participants were given \$50.00 to compensate them for their time. The study was approved by the Institutional Review Board at the Medical College of Wisconsin.

Theoretical Framework

The theoretical framework used for this study was the Health Belief Model (HBM), a framework that has proved useful in the exploration of inequities in cancer screening across race and ethnic groups (19–20). The HBM posits that the following factors are associated with decisions to undertake a preventive health behavior; perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and individual factors (21). The HBM further holds that people consider and balance these factors when deciding on whether to adopt a given health behavior such as a cancer screening recommendation.

Survey Elements

Individual level assessments included sociodemographic factors, health literacy, academic achievement in reading and arithmetic, knowledge about cancer screening guidelines, perceived cancer risks and worry, and perceived benefits and barriers to screening. The primary outcomes were self-reported screening behaviors. Health reading literacy was evaluated with Rapid Estimate of Adult Literacy in Medicine (REALM) (18). Health numeracy was assessed with the Lipkus expanded numeracy scale (22). Reading and arithmetic achievement were assessed with the Wide Range Achievement tests (WRAT-R and WRAT-A) (23). Factors in the domain of perceived susceptibility were measured by assessing perceived cancer risk and cancer worry. Perceived risk was measured on a five point Likert scale responding to the question “Would you say your chance of getting ‘insert cancer type’ cancer in the future is...” with a response scale of Very Low to Very High. Cancer worry was measured in response to the question “How often do you worry about getting ‘insert specific type’ cancer?” Responses were measured on a four point scale with the options of “Rarely or never”, “Sometimes”, “Often”, or “All the time.” Factors in the domain of perceived benefits and perceived severity were assessed on 5-point Likert scales that assessed seriousness of the disease, ability of the screening test to detect cancer early, association of early detection with more effective treatment, and perceived importance of screening test. Factors in the domain of perceived barriers were measured using 5-point Likert scales to assess perceived inconvenience, cost, pain, embarrassment, and fear of finding cancer.

The knowledge scale reflected two knowledge elements for each gender appropriate screening test; the recommended age at which to begin screening and the recommended interval of screening. Female subjects were asked about age and screening interval for mammography, Pap smear, fecal occult blood tests, and flexible sigmoidoscopy/colonoscopy (score range 0–8). Male subjects were asked knowledge questions regarding fecal occult blood tests, and flexible sigmoidoscopy/colonoscopy (score range 0–4). Knowledge assessments were rescaled to a scale of 0–10. Screening behaviors for breast, cervical, and colorectal cancer were measured using standardized questions from the CDC Behavioral Risk Factors Surveillance System Survey (24).

Analysis

A summary score of responses to the literacy and academic achievement measures, knowledge, worry, and perceived barriers and benefits was determined. Health numeracy was analyzed as a continuous measure using the Lipkus numeracy scale that has a range of

scores from 0–11. Cancer screening in accordance with guidelines was defined as having a mammogram within the past 2 years for women age 41 or older, a pap smear within the past 3 years for women with a uterus and less than or equal to age 65, a fecal occult blood test within the past year of a flexible sigmoidoscopy or colonoscopy within the past 10 years for men or women 51 years of age or older (25–28). Full cancer screening in accordance with guidelines was defined as having had all screening tests for which a given participant met eligibility criteria.

An analytic file was created with one observation per cancer eligibility. Logistic models that included cancer type as well as one additional factor were used to identify factors associated with cancer screening in a univariate analysis. Factors considered included sociodemographic characteristics, literacy and academic achievement measures, knowledge, perceived cancer risk and cancer worry, and perceived barriers and benefits to screening. A multivariate logistic regression model was used to evaluate independent predictors of cancer screening while controlling for variables that were associated with cancer screening in the univariate analysis. The logistic regression analysis used a general estimating equation approach in order to account for clustering due to multiple eligibilities per person. All non-binary covariates were standardized so that all exponentiated estimates of regression coefficients could be uniformly interpreted as odds ratios for individual's one standard deviation apart on the covariate scale. Odds ratios were converted to relative risks (29) using a baseline cancer screening rate of 0.85, the observed overall rate (Table 2).

Results

Study Population

Recruitment letters were mailed to 1938 persons. There were 611 persons who replied to the recruitment letter (32.0%). Of these 611, 11 (0.6% of total) were not able to be reached by phone, 51 (2.6% of total) met exclusion criteria, and 88 (4.5% of total) declined to participate. The primary reason for declining was “not interested”. Of the remaining 461 participants that were contacted and met inclusion criteria, 439 were scheduled for a visit (22.7%) and 369 (19%) presented for their interviews. Ten persons were excluded due to MMSE scores indicating cognitive dysfunction leading to a final survey sample of 359 persons (18.5%). Participants were older than non-participants (58.8 years (SD 8.9) vs. 57.4 years (SD 9.0), $p<0.01$). Participation rates varied by race; Whites (23.2%), Asian (20%), Blacks (13.8%), and Hispanics (6.2%), $p<0.001$, and were greater among females (19.9%) than males (15.4%) ($p=0.021$). The study population was diverse in income, race, education, reading and numeric health literacy, and academic achievement. Twelve percent (12%) had print health literacy measured at less than a 9th grade level (Table 1).

Cancer Screening Knowledge, Attitudes, and Behavior

Among the 359 respondents, 351 were eligible for one or more screening tests leading to 678 screening eligibilities. Seventy-six percent (76%) were up to date with all screening tests for which they were eligible. Rates of screening were higher for breast and cervical than for colorectal cancer (Table 2). The mean cancer screening knowledge (scale of 0–10) was 6.3 (SD 2.2). Participants generally viewed screening benefits to be high and barriers to

be low. On average, risk perceptions were rated between “somewhat low” and “moderate” and participants described that they worried about cancer between “rarely or never” and “sometimes” (Table 3).

Association of Health Numeracy with Participant Characteristics

Health numeracy, as measured by the Lipkus scale, was associated with higher levels of education ($p<0.001$), higher income ($p<0.001$), white race ($p<0.001$), married status ($p<0.001$), and male gender ($p=0.003$). Health numeracy was not correlated to overall perceived barriers (Spearman <0.01 , 95% CI -0.07 to 0.07), perceived benefits (Spearman -0.04 , 95% CI -0.12 to 0.03), or perceived cancer risk (Spearman -0.04 , 95% CI -0.11 to 0.04). However, participants with lower levels of health numeracy had higher levels of cancer worry (Spearman -0.14 , $p=0.0002$, CI -0.22 to -0.07) and with increased knowledge about cancer screening guidelines (Spearman 0.26 , 95% CI 0.16 – 0.35). The inverse association of health numeracy to cancer worry persisted after controlling for knowledge and print health literacy ($p<0.0001$).

Predictors of Cancer Screening Behaviors

We conducted a series of unadjusted analyses to evaluate the association of an individual participant characteristic with cancer screening adjusting for cancer type and clustering due to multiple cancer eligibilities per subjects. In this analysis we found that predictors of cancer screening according to guidelines included increased knowledge, decreased perceived barriers, increased perceived cancer screening benefits, higher levels of education, insurance coverage, and general numeracy as measured by the WRAT_A (Figure 1). In multivariate analysis, the GEE logistic model identified only three predictors of cancer screening behavior in accordance to recommended guidelines: cancer type, knowledge of screening tests, and perceived barriers to screening. Women were more likely to screen in accordance to guidelines for breast than colorectal cancer screening (RR 1.10, 95% CI 1.05–1.13) and for cervical than colorectal cancer screening (RR 1.11, 95% CI 1.05–1.16) (Table 4). Increased knowledge and decreased perceived barriers were also associated with cancer screening in multivariate analysis (Fig 2).

Discussion

In this study we sought to evaluate the independent relationship of health numeracy to cancer screening in accordance to guidelines using a framework of the Health Belief Model (HBM). Our methods allowed for a rich examination of the effects of specific domains of health literacy on cancer screening while controlling for education and other key elements of the HBM. Our results identified increased knowledge of cancer guidelines and decreased perceived barriers as predictors of cancer screening behavior in accordance to guidelines across cancer types. Health numeracy was not associated with cancer screening in this population.

Our study adds to the emerging literature on the relationship between health literacy and the adoption of health protective behaviors. Previous studies have established a relationship between health literacy, the ability to understand medical information (5), and knowledge of

cancer screening and prevention (6, 7). However, studies have reported mixed results with regard to the relationship of health literacy to cancer screening. In reviewing this literature, one must be cognizant of the prevalence of limited health literacy in study populations, measures used to assess health literacy, and the domain of health literacy evaluated. In a study of a Medicare managed care population, low print health literacy as measured by the Test of Functional Health Literacy in Adults (TOFHLA) was identified in almost 1/3 of the study population and associated with a lack of breast and cervical cancer screening (9). In a study of adults 65 years and older, below basic level of print literacy (29% of the study population) as measured by items in the National Assessment of Adult Literacy Survey was associated with decreased mammography use (10). In contrast, a clinical study among a university-affiliated internal medicine practice reports that limited print health literacy (48% of participants as measured by the REALM) was not associated with colorectal cancer screening (11). A study of patients recruited from a community health clinic in a medically underserved community (29% with limited health literacy as measured by the REALM) also reported no association between print health literacy and colorectal cancer screening (12). Our study had only 12% with print health literacy at less than the 9th grade level but similarly found no relationship of health literacy (reading or numeric) to cancer screening in a clinical population.

Our study focused on the domain of health numeracy. The health numeracy construct is relevant to decision making that involves balancing the risks and benefits of cancer screening interventions. Further, the age and interval based guidelines encompassed in cancer screening recommendations require a working knowledge of basic numeric concepts. Disease specific health numeracy skills have been associated with improved outcomes in chronic disease management including anticoagulation control (30), diabetes (31), and asthma (32). These studies focused on numeracy skills related to medication management. In a study of cancer screening behaviors among women in an urban academic medical center, Aggarwal found no association between numeracy and cancer screening (13). In her study, 26% of participants were found to be numerate as defined by understanding a probability concept, using frequencies to convey a probability, and the ability to compare the relative magnitude of five-year and lifetime risk. As in Aggarwal's study, we report no association between health numeracy and cancer screening in a primary care clinical population.

Our study did report two factors within the HBM framework that were predictive of increased rates of cancer screening in accordance with guidelines: knowledge of cancer screening recommendations (age at which screening begins and the recommended screening interval) and perceived barriers to screening. We found that fewer than 10% of participants knew the age and interval for all of the recommended cancer screening tests for their gender, a finding consistent with previous research reporting low levels of basic knowledge about screening tests for prostate cancer, breast cancer and colorectal cancer screening (12, 13, 33, 34). We also report that persons with lower perceived barriers have higher rates of cancer screening. This finding is consistent with previous studies reporting fear of cancer, fear of pain, and embarrassment to be significant predictors of lower screening rates for breast, prostate, colorectal, and cervical cancer (35–43).

Increased risk perceptions can both motivate and inhibit the adoption of health protective behaviors (44, 45). A moderately positive relationship has been found between risk perception mammography screening (44, 46). However, studies continue to indicate that this relationship is complex, with a recent study among women diverse in race and ethnicity finding a positive relationship between the perceived risk and colorectal cancer but not cervical or breast cancer screening (47). Our study found no relationship between risk perceptions and a pattern of cancer screening across the spectrum of cancers for which one is eligible.

We found health numeracy to be inversely related to cancer worry; a relationship that persisted after controlling for knowledge and print health literacy. Health numeracy has previously been found to be associated with the affect engendered by communicating numeric based risk information (16). The ability to understand probability and risk information may mitigate concerns about cancer worry. Further examination of this relationship is needed in order to understand its relevance to cancer risk communication and screening behavior.

Our study has some limitations. Cancer specific risk perceptions were assessed on a Likert scale with qualitative anchors and descriptors. Findings related to risk perception may have been different if a numeric (i.e., 0% to 100%) was used as scaling method has been shown to influence conveyed risk perceptions (48, 49). Participants were recruited from those enrolled in a primary care practice. The rates of cancer screening in our study population are higher than in population based studies for mammography, a finding that can be attributed to their access to primary care (3). In our study only 12% of participants had less than a 9th grade level of print health literacy as measured by the REALM. However, given the range in education, income, as well as reading and math achievement tests, we believe that this population is representative of many clinical practices.

In conclusion, this study found health numeracy to be associated with increased knowledge of cancer screening tests and decreased cancer worry. However, in a multivariate model no association between health numeracy and cancer screening in accordance to guidelines was found among a primary care population. Rather, we find the potentially modifiable factors of knowledge of cancer screening recommendations and perceived barriers to be significant predictors of cancer screening across participants of both lower and higher levels of numeracy. In summary, although health numeracy is theoretically important in order to understand the conceptual basis and practical application of cancer screening, further empiric evidence is needed to establish the role of health numeracy in the adoption of health protective behaviors such as cancer screening.

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Figure 1. Unadjusted Associations of Individual Characteristics with Cancer Screening

Association of participant characteristics with cancer screening in accordance with guidelines adjusted for cancer type and clustering due to multiple cancer eligibilities per subject. Odds ratios were converted to relative risks using a baseline adherence rate of 0.85, the observed overall rate. The p-value for the 2 degree of freedom test for education was 0.005, and for income was 0.056. See Table 2 for definitions of education and income levels.

Figure 2. Adjusted Associations of Individual Characteristics with Cancer Screening

Association of participant characteristics with cancer screening in accordance with guidelines adjusted for cancer type, clustering due to multiple cancer eligibilities per subject, knowledge about screening guidelines, and perceived barriers to cancer screening. Odds ratios were converted to relative risks using a baseline adherence rate of 0.85, the observed overall rate. The p-value for the two degree of freedom test for education was 0.06 and for income was 0.68. See Table 2 for definitions of education and income levels.

Table 1

Participant Characteristics

Participant Characteristic	n	%
Age in years (n=359)		
40–49	60	17
50–64	192	54
65–74	107	30
Gender (n=359)		
Male	90	25
Female	269	75
Race (n=359)		
White	251	70
Black	97	27
American Indian	5	1
Asian	6	2
Ethnicity (n=355)		
Non-Hispanic	345	97
Hispanic	10	3
Education (n=359)		
Up to 12 years	103	29
Some college	124	35
4 or more years of college	132	37
Income (n=344)		
\$14,999	62	18
\$15,000–\$74,999	188	55
\$75,000	94	27
Insurance (n=354)		
Yes	344	97
No	10	3
Marital Status (n=355)		
Married	186	52
Not married	169	48
Realm reading literacy		
<3 rd Grade (0–18)	1	<1
4 th –6 th grade (19–44)	7	2
7 th –8 th grade (45–60)	36	10
9 th grade (61–66)	315	88
Numeracy and Achievement	Mean	SD
Lipkus Numeracy	7.53	2.66
WRAT-A (Potential Range 15–55)	39.10	5.70
WRAT-R (Potential range 0–57)	48.40	6.18

Table 2**Cancer Screening Behavior**

	Eligible n	Cancer Screening n (%)
Breast Cancer Screening	262	234 (89)
Cervical Cancer Screening	133	122 (92)
Colorectal Cancer Screening	283	220 (78)
Overall: Eligible for Cancer Screening	678	576 (85)
Full Cancer Screening in Accordance with Guidelines	351*	267 (76)

Eligible participants were those that met criteria for screening based on gender, age, and clinical history per the following criteria: breast cancer: female, age 41 or older; cervical cancer: female, intact uterus, less than or equal to 65 years of age; colorectal cancer: 51 years of age. Cancer screening in accordance to guidelines was defined as follows; breast cancer: mammogram within the past 2 years; cervical cancer: Pap smear within the last 3 years; colorectal cancer: FOBT within the past year or flexible sigmoidoscopy or colonoscopy within the last 10 years. Full cancer screening in accordance with guidelines was defined as being up to date on all screening tests for which a given participant met eligibility criteria.

Table 3**Cancer Specific Perceived Benefits, Barriers, Risk, and Worry**

	Breast Cancer mean (SD)	Cervical Cancer mean (SD)	Colon Cancer Females mean (SD)	Colon Cancer Males mean (SD)
Perceived Benefits	1.20 (0.48)	1.17 (0.30)	1.30 (0.56)	1.36 (0.60)
Perceived Barriers	1.39 (0.58)	1.41 (0.55)	1.78 (0.73)	1.62 (0.74)
Risk Perceptions	2.50 (0.98)	2.20 (0.95)	2.32 (0.88)	2.48 (0.81)
Cancer Worry	1.71 (0.68)	1.43(0.65)	1.42 (0.58)	1.48 (0.61)

Note: Factors comprising the perceived benefits were assessed on 5-point Likert scales (1-Strongly agree to 5-Strongly Disagree) including perceived seriousness of disease, ability of screening test to detect cancer early, association of early detection with more effective treatment, and perceived importance of the screening test. Factors in the domain of perceived barriers were assessed on a 5-point Likert scale describing how much a factor discourages screening (1-Not at all to 5-Very Much). Risk Perceptions were assessed on a 5-point Likert scale describing “your chance of getting cancer” (1-Very Low to 5-Very High). Cancer worry was assessed on a 4-point scale describing how often you worry about getting cancer (1-Rarely or never; 2-Sometimes; 3-Often; 4-All the Time).

Table 4

Logistic Model Predicting Cancer Screening

Variable	RR	95% CI
Breast vs. cervical cancer	0.96	0.81–1.06
Breast vs. colorectal cancer (males)	1.06	0.97–1.12
Breast vs. colorectal cancer (females)	1.10	1.05–1.13
Cervical vs. colorectal (females)	1.11	1.05–1.16
Colorectal Male vs. Colorectal Female	1.05	0.95–1.11
Cancer Screening Knowledge	1.06	1.02–1.08
Perceived Barriers to Cancer Screening	0.94	0.92–0.95

Variables evaluated for inclusion in this model but not significant in the final model were age, education, income, race, ethnicity, insurance, reading literacy, health numeracy, perceived benefits to screening, and cancer worry. There were 678 eligible cancer screening cases among 351 persons. Relative risk for knowledge and perceived barriers represents relative risk with a 1 SD increase in score.