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Health Literacy, Health Numeracy, and Cancer Screening Patterns in the Zuni Pueblo: Insights from and Limitations of "Standard" Questions

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Abstract
American Indians experience disparities in cancer screening, stage at disease diagnoses, and 5-year cancer survival. This study investigates how health literacy and health numeracy may be linked to cancer screening behaviors of Zuni Pueblo members using a survey exploring screening behaviors related to breast, cervical, and colorectal cancers. As part of a larger community-based cancer prevention and control project, Zuni Health Initiative staff conducted surveys from October 2020 through April 2021 of 281 participants (men ages 50–75 and women ages 21–75) from the Zuni Pueblo. Bivariate and multivariable analyses investigated associations between health literacy/numeracy measures and cancer screening behaviors. Bivariate analyses showed some associations between distinct measures of health literacy/numeracy and colorectal cancer (CRC) screening, including both colonoscopy (health literacy) and fecal occult blood testing (FOBT) (health numeracy), as well as cervical cancer screening (health literacy). There were no statistically significant associations between health literacy/numeracy measures and mammogram screening for breast cancer. In multivariable analyses, there were no consistent patterns between health literacy/numeracy and screening for any cancer. There are some individual findings worth noting, such as statistically significant findings for health numeracy and FOBT (those reporting lower health numeracy were less likely to report FOBT). An important finding of this study is that questions used to assess health literacy/numeracy did not identify associations aligned with previous research. We reflect on the ways the "standard" questions may not be sufficiently tailored to the Zuni experience and may contribute to health equity barriers.

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Introduction

Cancer is a leading cause of death. In many historically medically underserved groups in the USA, cancer disparities emerge not only in incidence, but also in the severity of disease at diagnosis. Such patterns of disparity highlight the importance of early screening. As cancer treatments have evolved, guideline concordant screening for screen-detectable cancers allows for less invasive and more successful treatments, which leads to prolonged life and better quality of life. In cancer prevention and early detection scholarship, health literacy emerges as an important social determinant of cancer screening behaviors. However, most health literacy definitions and instruments have been developed based on the dominant Western culture and often are not validated or amended for cultural relevance (Thewes 2018; Yost 2017).

American Indians (AIs) experience disparities in cancer screening, advanced stage diagnoses, and 5-year cancer survival rates [11, 17]. Many disparities are linked to the lack of cultural competence in cancer care and the lack of culturally specific care coordination [12]. Population-health studies report on AIs as one group, which helps give broad understanding about the severity of disparities, but these studies cannot address tribe-specific disparities or needs. In response, a growing body of scholarship is exploring a wide range of causal factors by tribe to honor the diversity among AI tribes and to address disparities specific to tribes due to cultural and geographic factors, among others [21]. Specific cultural nuances, sources of stigma, and lack of culturally appropriate interventions emerge as candidate areas for improvement and innovation in cancer prevention [16, 21].

Scholarship suggests that people exhibiting higher levels of health literacy are more likely to have undergone cancer screening [4, 8, 9]. Health literacy intervention methods have proven to be effective tools in health decision-making processes [10]. AI health scholars argue that Indigenous culture and ways of knowing need to be at the foundation of any health literacy interventions, and that many current health literacy measures and interventions are not culturally appropriate for Indigenous communities [5],Yost 2017). The Health Behavior Framework (HBF) targets behavior change as a mechanism by which disparities are reduced, and models stemming from HBF further illustrate the relationship between health literacy and cancer screening modalities [1–3]. Within this, health literacy and interventions suggest that heightened levels of health literacy are important in enhancing overall health outcomes [4].

Our research explores the relationship between health literacy and numeracy and cancer screening patterns among adults in the Zuni Pueblo. The limited literature specific to Zuni cancer behaviors motivates our research. This study investigates how health literacy and numeracy may contribute to cancer screening behaviors among Zuni adults using a primary survey exploring screening behaviors related to screen-detectable cancers (i.e., breast, cervix, colon-rectum, and prostate).

Methods

Research Setting

This project stems from a cancer control survey conducted in the rurally situated Zuni Pueblo, which is the largest Pueblo Tribe in New Mexico, with approximately 11,000 residents. Based on 2021 population statistics, over 98% of residents are AI, the population is relatively young (median age approximately 33 years old), over 75% have a high school or higher level of education, and approximately one-third live below the poverty level (US Census, 2022). Some preventative cancer care is available at the Zuni Indian Health Service (IHS) Comprehensive Health Center, including Pap/HPV tests, mammograms, and iFOBT. Colonoscopies have to be referred to larger facilities, of which the Gallup IHS is the closest at 36 miles.

Sampling Strategy and Eligibility Criteria

The sampling strategy started with a complete enumeration of streets in the Pueblo which were then randomly sampled for recruitment. All households located on randomly sampled streets received a study recruitment flyer. Snowball sampling from these initial contacts and key community stakeholders was also employed. Finally, general participants were recruited through outreach at high traffic community locations, such as the post office and the local grocery store, and public service announcements on the community radio station. COVID-19 restrictions precluded active recruitment strategies. Eligibility included self-identifying as AI, a member of Zuni tribe or married to a Zuni tribal member, and meeting the age and gender requirements for the age/gender-specific survey. This project has received research approval from the Zuni Pueblo Tribal Council, the Southwest Tribal Institutional Review Board (IRB), and UNM Health Sciences Center IRB.

Study Implementation

The survey used an observational, cross-sectional design. The Zuni Health Initiative (ZHI) staff conducted surveys among eligible adult men ages 50–75 and women ages 21–75, between October 2020 and April 2021, in the Zuni

Pueblo. ZHI staff determined eligibility, consented, and administered the survey to interested participants. The survey varied in length based on the age/gender-specific survey. ZHI staff recruited 281 participants: 61 surveys were completed by women ages 21–49, 110 by women ages 50–75, and 110 by men ages 50–75. Due to COVID-19 pandemic precautions, ZHI staff conducted the majority of surveys over the phone, and used standard COVID-19 mitigation protocols when conducting in-person outreach and surveys. All participants received a merchandise card for their time. All survey responses were entered into REDCap by our data entry team.

Measures

The survey documented age/gender-specific cancer-related knowledge, attitudes, beliefs, and screening patterns regarding cancers of the breast, cervix, colon-rectum, and prostate. Additional questions included access to healthcare, health insurance, general health status, health literacy/numeracy, and socio-demographics. Women ages 21–49 were surveyed about cervical cancer; women ages 50–75 were surveyed about cervical, breast, and colorectal cancer; and men ages 50–75 were surveyed about colorectal and prostate cancer.

Health literacy was explored using several questions which measure different facets of health literacy (all rated on a 5-point Likert-style scale) [4]. First, print literacy is measured by the average score of the self-reports of the participant's ability to (1) understand written information about their health from a clinic (including from a doctor or nurse), (2) a participant's confidence in filling out medical forms, and (3) the preference of having material read by someone else (such as a family member). Then, spoken literacy is measured by the average score of the participant's confidence in their ability to (1) accurately explain to someone else what a health care provider told them, and (2) the likelihood they would ask a health care provider to explain something they said. We also analyze health literacy more broadly by using the combined average of print literacy and spoken literacy. Finally, numeracy is measured as the number answered correctly of two knowledge-based questions: (1) Which is the lower chance of getting a disease (1 in 10 people, 1 in 100 people, or 1 in 1000 people)?; and (2) If the chance of getting a health condition is 20 of 100 people, what is the percent chance (2%, 20%, or 200%)? (All questions modeled after Brega et al. [4].

Cancer screening for this analysis measures if a participant self-reports as having ever been screened for the specific type of cancer. The following screening types were surveyed: for cervical cancer, an HPV test and/or Pap test; for breast cancer, a mammogram; and for colorectal cancer, two screenings, a colonoscopy and a stool blood test.

Control variables include self-reported measures of income, education, employment, age, gender, health status, BMI, usual health care source, regular health care provider, and English language proficiency.

Data Analysis

The analysis for this project first assessed the descriptive statistics (summary and bivariate) of the individual health literacy and numeracy measures by cancer screening type, then analyzed the descriptive statistics (summary and bivariate) of the health literacy measures (including measures for print and spoken literacy) and health numeracy by cancer screening type. Bivariate associations were tested using the appropriate test (*t*-test or chi-squared test). Finally, logistic regression models were used to analyze the associations between health literacy and numeracy measures and cancer screening type, while controlling for key demographic characteristics.

Results

Cervical Cancer

Table 1 describes characteristics of the survey respondents. Of the 170 women with a valid response for the cervical cancer questions (1 missing cervical cancer responses), 129 women reported that they have had an HPV and/or Pap test (Table 1). In bivariate analysis, there was a statistically significant difference in the composite health literacy measure and in the more specific print literacy measure for those who reported having had an HPV and/or Pap test. There were no statistically significant differences between the screening groups for measures of spoken literacy or health numeracy. The group which reported having had a cervical cancer screening was older, had a higher level of education, and a greater percentage reported having a regular health care provider (all statistically significant with p values ≤ 0.05) (Table 1). However, after adjusting for key demographic characteristics in multivariable analysis there were no statistically significant patterns between health literacy or health numeracy measures and having had an HPV and/or Pap test. The only statistically significant pattern in the multivariable models was age: each additional year of age is associated with a 1.06-fold higher odds of reporting having had a screening (95% CI: 1.02–1.09) (Table 2).

Breast Cancer

Of the 110 participants eligible for breast cancer screening questions, 95 reported they have had a mammogram. There were no statistically significant differences between those

Table 1 Descriptive statistics for the health literacy/numeracy measures and control variables by self-reported cancer screening types

Variables	Pap/HPV			Mammogram			Colonoscopy			FOBT		
(% or mean)	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes
Ever screened (self-report)	0.759	0.000	1.000	0.864	0.000	1.000	0.365	0.000	1.000	0.429	0.000	1.000
	(0.429)	(0.000)	(0.000)	(0.345)	(0.000)	(0.000)	(0.483)	(0.000)	(0.000)	(0.496)	(0.000)	(0.000)
Health literacy	3.259	**3.078**	**3.316**	3.184	3.253	3.173	3.203	3.249	3.122	3.200	3.197	3.204
	(0.633)	**(0.751)**	**(0.582)**	(0.666)	(0.798)	(0.647)	(0.629)	(0.629)	(0.624)	(0.629)	(0.598)	(0.672)
Print literacy	3.622	**3.382**	**3.698**	3.494	3.600	3.477	3.488	3.548	3.383	3.484	3.460	3.516
	(0.886)	**(1.063)**	**(0.812)**	(0.914)	(1.114)	(0.884)	(0.850)	(0.856)	(0.835)	(0.850)	(0.839)	(0.869)
Spoken literacy	2.715	2.622	2.744	2.718	2.733	2.716	2.775	2.801	2.731	2.774	2.802	2.737
	(0.703)	(0.789)	(0.673)	(0.756)	(0.729)	(0.764)	(0.739)	(0.714)	(0.783)	(0.740)	(0.738)	(0.747)
Numeracy score (mean score)	0.941	1.000	0.922	0.900	0.733	0.926	0.932	0.928	0.950	0.931	0.871	1.011
	(0.603)	(0.671)	(0.581)	(0.590)	(0.594)	(0.588)	(0.583)	(0.575)	(0.593)	(0.577)	(0.611)	(0.521)
Female	–	–	–	–	–	–	0.498	0.486	0.525	0.502	**0.435**	**0.591**
	–	–	–	–	–	–	(0.501)	(0.502)	(0.503)	(0.501)	**(0.498)**	**(0.494)**
Age	52.20	**44.19**	**54.74**	60.61	**55.03**	**61.48**	59.73	**58.24**	**62.38**	59.81	**58.03**	**62.18**
	(14.06)	**(16.00)**	**(12.41)**	(7.531)	**(4.540)**	**(7.547)**	(7.027)	**(6.368)**	**(7.367)**	(7.009)	**(6.336)**	**(7.193)**
SRH	2.888	2.976	2.860	2.855	**3.267**	**2.789**	3.018	3.109	2.862	3.023	3.089	2.935
	(0.873)	(0.821)	(0.890)	(0.811)	**(0.704)**	**(0.811)**	(0.943)	(0.910)	(0.990)	(0.945)	(1.012)	(0.845)
Regular provider	0.629	**0.439**	**0.690**	0.700	**0.467**	**0.737**	0.607	0.507	0.775	0.604	**0.484**	**0.763**
	(0.484)	**(0.502)**	**(0.464)**	(0.460)	**(0.516)**	**(0.443)**	(0.489)	(0.502)	(0.420)	(0.490)	**(0.502)**	**(0.427)**
Income												
< $10,000	0.400	0.512	0.364	0.364	0.467	0.347	0.425	**0.493**	**0.300**	0.424	**0.476**	**0.355**
	(0.491)	(0.506)	(0.483)	(0.483)	(0.516)	(0.479)	(0.495)	**(0.502)**	**(0.461)**	(0.495)	**(0.501)**	**(0.481)**
$10,000–39,999	0.482	0.390	0.512	0.509	0.400	0.526	0.443	**0.413**	**0.500**	0.447	**0.435**	**0.462**
	(0.501)	(0.494)	(0.502)	(0.502)	(0.507)	(0.502)	(0.498)	**(0.494)**	**(0.503)**	(0.498)	**(0.498)**	**(0.501)**
> $40,000	0.100	0.0732	0.109	0.109	0.133	0.105	0.100	**0.087**	**0.125**	0.097	**0.081**	**0.118**
	(0.301)	(0.264)	(0.312)	(0.313)	(0.352)	(0.309)	(0.301)	**(0.283)**	**(0.333)**	(0.296)	**(0.273)**	**(0.325)**
Missing	0.018	0.024	0.016	0.018	0.000	0.021	0.0320	**0.007**	**0.075**	0.032	**0.008**	**0.065**
	(0.132)	(0.156)	(0.124)	(0.134)	(0.000)	(0.144)	(0.176)	**(0.085)**	**(0.265)**	(0.177)	**(0.090)**	**(0.247)**
Education level												
< High school	0.171	0.220	0.155	0.164	0.133	0.168	0.151	0.145	0.163	0.152	0.161	0.140
	(0.377)	(0.419)	(0.363)	(0.372)	(0.352)	(0.376)	(0.359)	(0.353)	(0.371)	(0.360)	(0.369)	(0.349)
HS/GED	0.324	0.415	0.295	0.336	0.400	0.326	0.397	0.420	0.350	0.396	0.419	0.366
	(0.469)	(0.499)	(0.458)	(0.475)	(0.507)	(0.471)	(0.490)	(0.495)	(0.480)	(0.490)	(0.495)	(0.484)
> High school	0.506	0.366	0.550	0.500	0.467	0.505	0.452	0.435	0.487	0.452	0.419	0.495
	(0.501)	(0.488)	(0.499)	(0.502)	(0.516)	(0.503)	(0.499)	(0.498)	(0.503)	(0.499)	(0.495)	(0.503)
Employment												
Employed	0.229	0.244	0.225	0.182	**0.200**	**0.179**	0.155	**0.145**	**0.175**	0.152	**0.121**	**0.194**
	(0.422)	(0.435)	(0.419)	(0.387)	**(0.414)**	**(0.385)**	(0.363)	**(0.353)**	**(0.382)**	(0.360)	**(0.327)**	**(0.397)**
Self-employed	0.259	0.220	0.271	0.264	**0.600**	**0.211**	0.342	**0.399**	**0.250**	0.346	**0.395**	**0.280**
	(0.439)	(0.419)	(0.446)	(0.443)	**(0.507)**	**(0.410)**	(0.476)	**(0.491)**	**(0.436)**	(0.477)	**(0.491)**	**(0.451)**
Unemployed	0.124	0.195	0.101	0.073	**0.067**	**0.074**	0.123	**0.145**	**0.0750**	0.120	**0.169**	**0.054**
	(0.330)	(0.401)	(0.302)	(0.261)	**(0.258)**	**(0.263)**	(0.330)	**(0.353)**	**(0.265)**	(0.325)	**(0.377)**	**(0.227)**
Not in labor force	0.388	0.341	0.403	0.482	**0.133**	**0.537**	0.379	**0.312**	**0.500**	0.382	**0.315**	**0.473**
	(0.489)	(0.480)	(0.492)	(0.502)	**(0.352)**	**(0.501)**	(0.486)	**(0.465)**	**(0.503)**	(0.487)	**(0.466)**	**(0.502)**
Observations	170	41	129	110	15	95	219	138	80	217	124	93

Standard deviation in parentheses. **Bold** indicates *p* value of *t*-test/chi-square test ≤ 0.05

Table 2 Logistic regression of health literacy/numeracy and self-reported cancer screening with control variables, odds ratios

Variables	Pap/HPV		Mammogram		Colonoscopy		FOBT	
(omitted category)	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Health literacy	1.8164	–	1.0096	–	0.7945	–	0.9961	–
	(0.861–3.831)	–	(0.279–3.653)	–	(0.455–1.386)	–	(0.575–1.725)	–
Print literacy	–	1.5784	–	0.6591	–	0.8058	–	1.0818
	–	(0.944–2.639)	–	(0.225–1.929)	–	(0.532–1.220)	–	(0.719–1.627)
Spoken literacy	–	0.9968	–	2.0105	–	1.0328	–	0.8726
	–	(0.506–1.964)	–	(0.543–7.450)	–	(0.659–1.619)	–	(0.553–1.377)
Numeracy score (0 correct)								
1 correct	1.0297	1.0077	1.4232	1.9115	0.8362	0.8261	**2.8687***	**2.9016***
	(0.351–3.019)	(0.340–2.985)	(0.211–9.596)	(0.264–13.837)	(0.368–1.900)	(0.363–1.879)	**(1.195–6.886)**	**(1.205–6.988)**
2 correct	0.4343	0.4208	3.8353	3.5203	0.8202	0.8270	2.0970	2.0825
	(0.105–1.793)	(0.101–1.756)	(0.137–107.686)	(0.127–97.842)	(0.267–2.523)	(0.269–2.543)	(0.662–6.640)	(0.656–6.609)
Female	–	–	–	–	0.6195	0.6234	1.2915	1.2765
	–	–	–	–	(0.312–1.228)	(0.314–1.238)	(0.661–2.523)	(0.652–2.498)
Age	**1.0561****	**1.0572****	**1.2729****	**1.2747****	**1.0772****	**1.0778****	**1.0690***	**1.0692***
	(1.021–1.092)	**(1.022–1.093)**	**(1.062–1.525)**	**(1.070–1.519)**	**(1.023–1.134)**	**(1.024–1.135)**	**(1.016–1.125)**	**(1.016–1.126)**
High SRH	1.6938	1.8520	0.1209	0.123	0.7790	0.7587	0.5946	0.6127
	(0.547–5.241)	(0.581–5.906)	(0.013–1.129)	(0.013–1.125)	(0.361–1.680)	(0.350–1.644)	(0.273–1.293)	(0.280–1.341)
Regular provider	1.8098	1.8368	2.2425	3.3101	**2.5731****	**2.5830****	**2.7742****	**2.7716****
	(0.747–4.382)	(0.755–4.471)	(0.376–13.38)	(0.463–23.64)	**(1.256–5.270)**	**(1.260–5.294)**	**(1.387–5.549)**	**(1.385–5.545)**
Income (< $10,000)								
$10,000–39,999	1.5891	1.6236	3.3604	2.4871	1.9465	1.9296	0.9899	1.0088
	(0.636–3.971)	(0.648–4.065)	(0.489–23.08)	(0.331–18.71)	(0.961–3.942)	(0.952–3.911)	(0.495–1.980)	(0.504–2.021)
> $40,000	1.4950	1.3676	1.6365	1.6766	2.7451	2.7852	1.9785	1.9826
	(0.314–7.124)	(0.282–6.626)	(0.117–22.87)	(0.114–24.68)	(0.950–7.934)	(0.965–8.040)	(0.665–5.884)	(0.662–5.938)
Education level (< high school)								
HS/GED	0.9205	0.9415	0.0707	0.0685	0.6084	0.6208	0.8350	0.8144
	(0.283–2.994)	(0.290–3.056)	(0.003–1.726)	(0.003–1.774)	(0.232–1.594)	(0.236–1.635)	(0.316–2.204)	(0.308–2.153)
> High school	1.2898	1.2814	0.0546	0.0699	0.6197	0.6513	0.7775	0.7333
	(0.392–4.245)	(0.390–4.209)	(0.002–1.404)	(0.003–1.924)	(0.224–1.718)	(0.231–1.833)	(0.279–2.164)	(0.260–2.067)
Employment (employed)								
Self-employed	1.1511	1.2366	0.1634	0.147	0.5706	0.5558	0.4791	0.4926
	(0.341–3.881)	(0.360–4.248)	(0.022–1.228)	(0.018–1.175)	(0.217–1.500)	(0.210–1.468)	(0.187–1.226)	(0.192–1.267)
Unemployed	0.6400	0.6081	1.7947	2.8457	0.5142	0.5332	**0.2023***	**0.1955***
	(0.165–2.490)	(0.156–2.374)	(0.105–30.78)	(0.123–65.90)	(0.146–1.814)	(0.150–1.893)	**(0.054–0.764)**	**(0.052–0.741)**
Not in labor force	1.0095	1.0552	2.5579	2.4605	0.7876	0.7754	0.5681	0.5781
	(0.323–3.154)	(0.335–3.321)	(0.198–33.00)	(0.183–33.07)	(0.302–2.055)	(0.296–2.028)	(0.219–1.474)	(0.222–1.502)
Constant	0.0034**	0.0046*	0.0000*	0.0000*	0.0065*	0.0055*	0.0112*	0.0126*
	(0.000–0.257)	(0.000–0.356)	(0.000–0.224)	(0.000–0.114)	(0.000–0.444)	(0.000–0.392)	(0.000–0.767)	(0.000–0.870)
Observations	168	168	110	110	218	218	217	217

ciEfrom in parentheses. **Bold** indicates p value ≤ 0.05; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

All models are also adjusted for English proficiency/additional language spoken, marital status, and BMI

who have had a screening and those who have not in any of the health literacy or health numeracy measures. However, there are several demographic differences between the two groups. Those who reported having had a mammogram were older, less likely to be in the labor force, more likely to report having a regular provider, and had poorer self-rated health (all statistically significant with p values ≤ 0.05). After adjusting for demographic characteristics in multivariable analysis, there were no statistically significant patterns between any health literacy or health numeracy measure and having had a mammogram. Only age and BMI were statistically significant in the multivariable models: when adjusting for other factors, each additional year of age was associated with a 1.27-fold higher odds of reporting having had a screening (95% CI: 1.07–1.52), and having a BMI one point higher was associated with a 1.25-fold higher odds of reporting having had a screening (95% CI: 1.02–1.52) (Table 2).

Colorectal Cancer

Of the 219 participants eligible for colorectal cancer screenings, 80 reported having had a colonoscopy and 93 reported having had a FOBT (Table 1). While these groups were largely similar, there are some differences. Neither group had a statistically significant association between any of the health literacy measures and having either screening. However, while there was no statistically significant association between health numeracy and colonoscopies, those with higher health numeracy scores were more likely to report having had a FOBT.

The group which reported having had a colonoscopy was statistically significantly different than the group which did not in several ways. The group reporting having had a colonoscopy was older, reported higher levels of income, and reported different employment patterns (including a lower percentage of self-employed and unemployed in addition to a higher portion of people not in the labor force) (all statistically significant with p values ≤ 0.05) (Table 1). The group which reported having had a FOBT is statistically significantly different than the group which did not in several ways. Those reporting having had a FOBT were more likely to be female, be older, report having a regular provider, report higher levels of income, and report different employment patterns (including a lower percentage of self-employed and unemployed in addition to a higher portion of people not in labor force) (all statistically significant with p values ≤ 0.05) (Table 1).

After adjusting for demographic characteristics in the multivariable analyses, there were no statistically significant patterns between any health literacy or health numeracy measure and having had a colonoscopy. The statistically significant factors in the multivariable models were age and regular provider: each additional year of age was associated with a 1.08-fold higher odds of reporting having had a screening (95% CI: 1.02–1.14) and having a regular provider was associated with a 2.58-fold higher odds of reporting having had a screening (95% CI: 1.26–5.29) (Table 2). For those reporting FOBT, there was a statistically significant association between health numeracy and having had a FOBT. Compared to those who answered zero health numeracy questions correctly, having answered one health numeracy question correctly was associated with a 2.90-fold higher odds of reporting having had a screening (95% CI: 1.21–6.99). However, the significance does not hold for those who answered both correctly compared to zero. The statistically significant patterns in the multivariable models are age, regular provider, and employment: each additional year of age was associated with a 1.07-fold higher odds of reporting having had a screening (95% CI: 1.02–1.13); having a regular provider was associated with a 2.78-fold higher odds of reporting having had a screening (95% CI: 1.39–5.55); and compared to those who are employed, being unemployed was associated with a 0.20 odds of reporting having had a screening (95% CI: 0.05–0.74) (Table 2).

Individual Questions

To better understand what the health literacy and health numeracy questions are capturing, we analyzed the associations between each individual question and cancer screening type (Table 3). These analyses show that many questions have associations of unexpected direction (as when people with a lower score on a health literacy question report a higher odds of having a screening). In addition to the unexpected direction of association, one question also stands out for having a distinctly different answering pattern: How likely is it that you would ask your health care provider to clarify something she or he said? This question has notably lower scores across all cancer screening types.

Discussion

This study evaluated self-reported cancer screening of Zuni adults living in Zuni Pueblo. There was no strong evidence to support our hypotheses that health literacy and numeracy would be associated with self-reported cancer screening for breast, cervical, and colorectal cancers. While many studies have confirmed such associations, many others have not. In a recent systematic review of 14 analyses of health literacy and cancer screening, seven found a significant positive relationship, one found a significant negative relationship, and six found no significant association [14]. However, the association between health literacy (specifically print literacy) and HPV/Pap tests and health numeracy and FOBT gives some justification for further exploring how health literacy

Table 3 Descriptive statistics of health literacy and numeracy questions by self-reported cancer screening type

Health literacy/numeracy (mean score/percent correct)	Pap/HPV			Mammogram			Colonoscopy			FOBT		
	No ($n=41$)	Yes ($n=129$)	*t*-Test (*p* value)	No ($n=15$)	Yes ($n=95$)	*t*-Test (*p* value)	No ($n=138$)	Yes ($n=80$)	*t*-Test (*p* value)	No ($n=124$)	Yes ($n=93$)	*t*-Test (*p* value)
How often do you have a hard time understanding written information about your health that you get from your clinic? (This might include information from a doctor or nurse.)	3.390	3.636	− 1.219 (0.224)	3.467	3.505	− 0.118 (0.906)	3.449	3.513	− 0.373 (0.709)	3.371	3.602	− 1.401 (0.163)
How confident are you in filling out medical forms by yourself?	3.634	3.907	− 1.468 (0.144)	3.600	3.684	− 0.278 (0.781)	*3.804*	*3.613*	*1.299 (0.195)*	3.661	3.817	− 1.081 (0.281)
How often do you prefer that someone (like a family member or someone else) helps you read medical materials?	3.122	3.550	− 1.919 (0.056)	*3.733*	*3.242*	*1.425 (0.157)*	***3.391***	***3.025***	***2.088 (0.038)***	*3.467*	*3.129*	*1.261 (0.209)*

Table 3 (continued)

Health literacy/ numeracy	Pap/HPV			Mammogram			Colonoscopy			FOBT		
(mean score/ percent correct)	No ($n=41$)	Yes ($n=129$)	*t*-Test (*p* value)	No ($n=15$)	Yes ($n=95$)	*t*-Test (*p* value)	No ($n=138$)	Yes ($n=80$)	*t*-Test (*p* value)	No ($n=124$)	Yes ($n=93$)	*t*-Test (*p* value)
How confident are you that you will be able to accurately explain what your health care provider told you to a friend or family member?	**3.146**	**3.590**	**−2.229 (0.027)**	*3.533*	*3.453*	*0.256 (0.799)*	*3.623*	*3.500*	*0.811 (0.418)*	*3.637*	*3.495*	*0.960 (0.338)*
How likely is it that you would ask your health care provider to explain or clarify something she or he said?	*2.098*	*1.899*	*1.089 (0.278)*	1.933	1.979	−0.1592 (0.874)	*1.978*	*1.963*	*0.108 (0.9143)*	1.968	1.978	−0.075 (0.940)

Table 3 (continued)

Health literacy/ numeracy	Pap/HPV			Mammogram			Colonoscopy			FOBT		
(mean score/ percent correct)	No ($n=41$)	Yes ($n=129$)	*t*-Test (p value)	No ($n=15$)	Yes ($n=95$)	*t*-Test (p value)	No ($n=138$)	Yes ($n=80$)	*t*-Test (p value)	No ($n=124$)	Yes ($n=93$)	*t*-Test (p value)
Which of the following numbers means a lower chance of getting a disease? That is, which would you most like to hear from a doctor about your risk for a medical condition?	*0.293*	*0.287*	*0.072 (0.943)*	0.200	0.337	−1.053 (0.295)	*0.302*	*0.049*	*0.823 (0.412)*	0.272	0.290	−0.297 (0.767)
If the chance of getting a health condition is 20 out of 100 people, this would be the same as having what percent (%) chance of getting the condition?	*0.707*	*0.636*	*0.836 (0.404)*	0.533	0.590	−0.406 (0.6854)	0.619	0.700	−1.212 (0.227)	**0.592**	**0.720**	**−1.971 (0.050)**

Bold indicates p value ≤ 0.05. *Italics* indicate opposite direction of hypothesis

may play a role in improving cancer screening behaviors. Across all cancer types, as people get older, they were more likely to report being screened. As we develop interventions, we should consider the specific contexts of younger people to improve cancer screening patterns.

While our findings of non-significant relationships between health literacy and cancer screening do not align with many studies, other research in this area suggests contextual factors such as community-level access, including insurance coverage, timeliness of receipt of care, distance to healthcare facilities, and concentration of providers, as well as ethnic density and community-level poverty measures, can serve as confounders of health literacy and cancer screening [6, 13, 18], Pourat et al. 2010). These contextual factors have been correlated with cancer screening beyond the individual-level measures that are assessed with health literacy and numeracy [14, 18]. The mechanism for this confounding can be understood by considering two identical individuals with low health literacy. If one of these individuals lives in a community with relatively few barriers to medical care, a high ethnic density, and lower overall poverty rates, that individual will more easily overcome the cancer screening barriers presented by low health literacy than the same individual in a community with many barriers to medical care, a low ethnic density, and higher overall poverty rates. Indeed, all Zuni participants of this study reside in a community with high ethnic density and have access to an Indian Health Service run comprehensive health center without a health insurance requirement. As such, it is possible, even likely, that these contextual factors outweigh the relationship between health literacy and cancer screening as was partially observed in our bivariate analyses. This finding generally aligns with the current belief that cancer screening interventions should be multilevel.

Finally, a closer examination of the health literacy question indicate that these questions may have not been the most effective questions for screening health literacy in Zuni Pueblo. For example, the question that explores people's preference for family members or someone else to help read medical materials could be measuring presence of social support or the reflecting the value placed on group decision-making instead of measuring an inability to read medical materials independently. This would help explain why those who prefer help reading medical materials also reported higher likelihood of having had a cervical cancer screening. Health literacy researchers should carefully consider which questions capture health literacy and health numeracy more effectively and culturally appropriately to better understand how to bolster cancer screening patterns through culturally informed educational efforts.

There are some limitations of this study. The sampling strategy employed several different recruitment plans, but was not random nor representative. In addition to the sampling strategy, this is a cross-sectional survey with a relatively small sample size, so there are limitations to the causal inferences we can make from our results. This paper is intended to provide insights into health literacy knowledge in Zuni and add to discussions about the measurement of health literacy, but this paper cannot speak to changes in cancer screening behaviors nor changes in health literacy over time. Finally, this survey was conducted during the COVID-19 pandemic, when there were additional barriers to accessing health care, which may have limited our participants' ability to access cancer screenings during this time. Finally, all information is self-reported.

Conclusion

This study indicates that assumptions should not be made about health literacy and cancer screening behaviors in AI health studies. To determine if health literacy interventions are appropriate for improving Zuni cancer screening behaviors, additional research exploring different measures of health literacy is needed. As having a regular provider was associated with cancer screening behaviors in the bivariate (cervical, breast, and colorectal cancers) and the multivariate (colorectal cancer), there are some implications for practice. Efforts aiming to improve continuity of care are important, and when provider turnover occurs, additional efforts should be made to support patients during a transition to a new provider. These findings also show strengths in the Zuni community, including access to care and implications for social support. Ultimately, these findings add evidence that all efforts to measure and improve health literacy should be tested and tailored to priority populations.

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Declarations

Conflict of Interest The authors declare no competing interests.

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