Association of Numeracy with Self-Reported Health Status and Healthcare-Provider Visits

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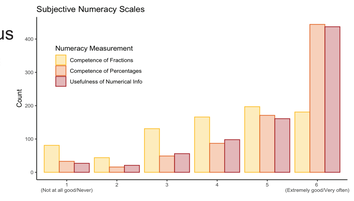
Introduction

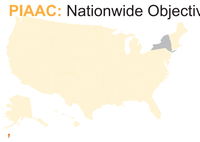
Numeracy, the aptitude with probabilities, fractions, and ratios, is essential to understand the treatment decisions in healthcare communication. Using validated **Subjective Numeracy Scale (SNS)** 3-item scale, we have tested the hypothesis that numeracy is associated with self-reported health, and visits to healthcare providers. Data was collected as part of the **Empire State Poll 2019 (ESP),** a random digit-dial telephone statewide survey of 800 New York State residents who are at least 18 years of age. Regression weights are computed using the **New York State Census Data 2019**. Moreover, for the association between numeracy and self-reported health status specifically, we perform similar analysis within the datasets of US. from International **Assessment of Adult Competencies (PIAAC) 2017.**

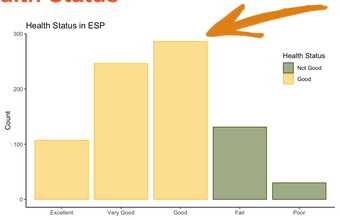


Outcome 1: Self-Reported Health Status

- **Binary Variable**
- **Data Sources:**

NYS: Weighted calculation
ESP: Statewide Subjective Numeracy
PIAAC: Nationwide Objective Numeracy

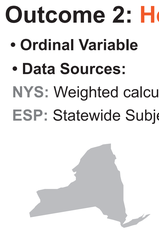


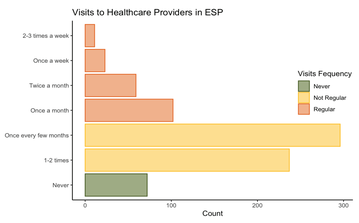


Outcome 2: Healthcare-Provider Visits

- **Ordinal Variable**
- **Data Sources:**

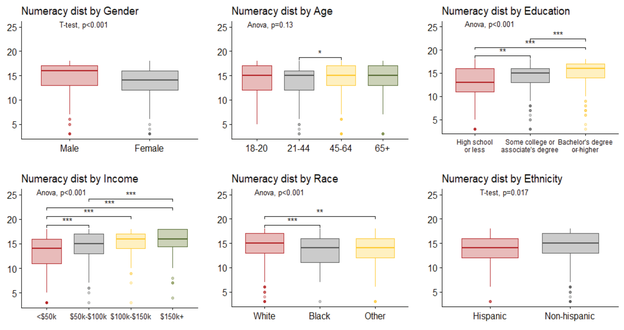
NYS: Weighted calculation
ESP: Statewide Subjective Numeracy

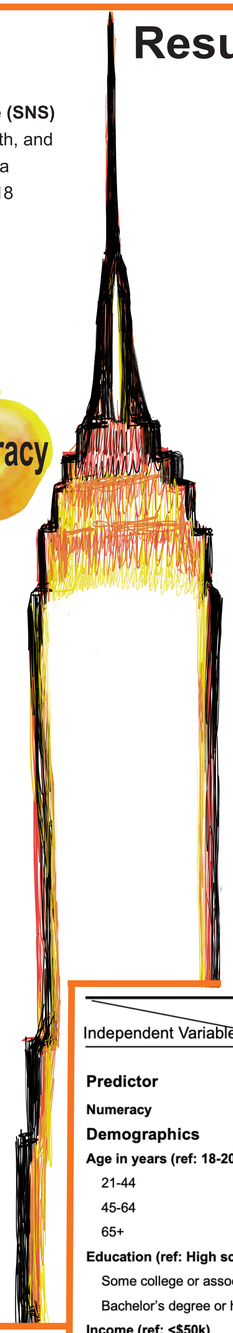




Covariates

1. Age
2. Education
3. Income
4. Ethnicity
5. Race
6. Gender





Result

NYS VS. ESP

Demographics Comparison

Demographic Covariates	NYS	ESP	P-value
Education			<0.001 ***
High school or less	97506(38.92%)	173(22.67%)	
Some college or associate's degree	69577(27.77%)	216(28.31%)	
Bachelor's degree or higher	83478(33.32%)	374(49.02%)	
Income			<0.001 ***
<$50k	51303(33.03%)	252(33.03%)	
$50k-$100k	64932(41.8%)	259(33.94%)	
$100k-$150k	19158(12.33%)	109(14.29%)	
$150k+	19930(12.83%)	143(18.74%)	
Race			<0.001 ***
White	13559(69.7%)	522(68.41%)	
Black	3424(17.6%)	98(12.84%)	
Other	2471(12.7%)	143(18.74%)	
Ethnicity			0.494
Hispanic	41217(16.47%)	118(15.47%)	
Non-Hispanic	209046(83.53%)	645(84.53%)	
Gender			0.157
Male	121301(48.41%)	389(50.98%)	
Female	129262(51.59%)	374(49.02%)	
Age in years			0.16
18-20	11851(4.73%)	41(5.37%)	
21-44	103469(41.29%)	288(37.75%)	
45-64	82455(32.91%)	274(35.91%)	
65+	52788(21.07%)	160(20.97%)	

Significance Annotation: P-value 0 *** 0.001 ** 0.01 * 0.05

Note: P-value is calculated by Fisher's test

Health Status

PIAAC VS. ESP

Association between Heath Status and Numeracy

Models / Independent Variables	Unweighted ESP (N=763)		Weighted ESP (N=763)		PIAAC (N=2609)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Predictor						
Numeracy	0.94 (0.89-1)	0.038 *	0.93 (0.88-0.98)	0.005 **	0.99 (0.99-1)	0.016 *
Demographics						
Age in years (ref: 18-20)						
21-44	4.82 (1.6-20.96)	0.013 *	4.89 (1.86-16.29)	0.003 **	1.14 (0.68-2.01)	0.642
45-64	4.88 (1.61-21.23)	0.013 *	5.92 (2.25-19.81)	0.001 **	2.18 (1.29-3.87)	0.005 **
65+	6.86 (2.23-30.17)	0.003 **	7.2 (2.67-24.5)	<0.001 ***	2.33(1.26-4.46)	0.009 **
Education (ref: High school or less)						
Some college or associate's degree	0.43 (0.27-0.7)	<0.001 ***	0.51 (0.32-0.8)	0.003 **	0.71 (0.52-0.95)	0.024 *
Bachelor's degree or higher	0.3 (0.18-0.49)	<0.001 ***	0.36 (0.21-0.59)	<0.001 ***	0.54 (0.39-0.74)	<0.001 ***
Income (ref: <$50k)						
$50k-$100k	0.42 (0.26-0.67)	<0.001 ***	0.39 (0.25-0.59)	<0.001 ***	0.51 (0.39-0.66)	<0.001 ***
$100k-$150k	0.64 (0.34-1.16)	0.151	0.56 (0.29-1.03)	0.07	0.31 (0.20-0.48)	<0.001 ***
$150k+	0.46 (0.23-0.86)	0.017 *	0.45 (0.21-0.89)	0.027 *	0.34 (0.20-0.54)	<0.001 ***
Ethnicity (ref: Hispanic)						
Non-Hispanic	/	/	0.58 (0.37-0.91)	0.017 *	/	/

Significance Annotation: P-value 0 *** 0.001 ** 0.01 * 0.05

OR Annotation: Significantly > 1 Significantly <1

Blank cells with "/": NA, because those variables do not show in the final model using stepwise selection method with both directions.

Note: Race and Gender are not been selected in all three final models using stepwise selection method with both directions.

Performance

AUC	0.724	0.72	0.692
Power	0.81	0.574	0.63
Prediction Error	0.219	0.219	0.152

Method

1. **Hypothesis Testing:** Fisher's test, Chisq test, t-test, ANOVA
2. **Correaltion:** Polychoric, Point-Biserial
3. **Model Building**

- Post-stratification weights: Iterative method $\text{weight} = \frac{\text{Population Proportion}}{\text{Sample Proportion}}$
- Generalized Linear Regression

Self-Reported Status

Logistic Regression

$$\log\left(\frac{P(Y=1)}{P(Y=0)}\right) = \log\frac{\pi}{1-\pi} = \beta_{k0} + \beta_{k1}x_1 + \ ... + \beta_{kp}x_p$$

Healthcare-Provider Visits

Ordinal Logistic Regression

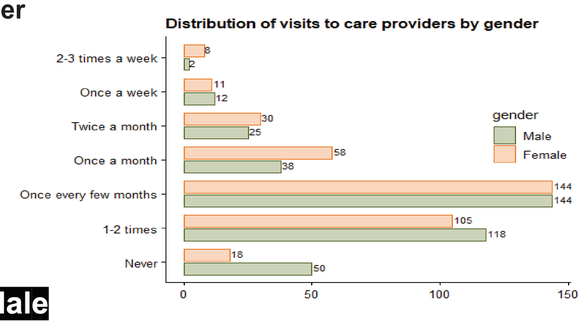
$$\log\left(\frac{P(Y=k)}{P(Y=0)}\right) = \log\frac{\pi_k}{\pi_1} = \beta_{k0} + \beta_{k1}x_1 + \ ... + \beta_{kp}x_p$$

4. **Model Performance Evaluation**

Power Analysis by simulating ESP data for 100 times, AUC, Prediction Error

Healthcare-Provider Visits

Subset by Gender



Female VS. Male

Association between Healthcare-Provider Visitis and Numeracy

Models / Independent Variables	Unweighted Female (N=374)		Unweighted Male (N=389)		Weighted Male (N=389)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Predictor						
Numeracy	/	/	0.92 (0.85-0.99)	0.036 *	0.91 (0.84-0.98)	0.008 **
Demographics						
Age in years (ref: 18-20)						
21-44	1.86 (0.64-5.8)	0.268	0.54 (0.22-1.32)	0.176	0.38 (0.16-0.86)	0.021 *
45-64	0.86 (0.3-2.67)	0.785	0.8 (0.32-2.02)	0.641	0.67 (0.29-1.57)	0.357
65+	1.47 (0.5-4.72)	0.498	1.65 (0.63-4.37)	0.31	1.17 (0.48-2.92)	0.731
Education (ref: High school or less)						
Some college or associate's degree	/	/	/	/	1.74 (1.02-2.97)	0.042 *
Bachelor's degree or higher	/	/	/	/	1.73 (0.99-3.04)	0.054
Income (ref: <$50k)						
$50k-$100k	/	/	1.47 (0.84-2.59)	0.182	1.25 (0.73-2.16)	0.411
$100k-$150k	/	/	1.33 (0.67-2.65)	0.422	0.86 (0.43-1.72)	0.663
$150k+	/	/	2.44 (1.28-4.68)	0.007 **	2.02 (1.03-3.97)	0.041 *
Ethnicity (ref: Hispanic)						
Non-Hispanic	/	/	/	/	2.03 (1.12-3.7)	0.02 *

Significance Annotation: P-value 0 *** 0.001 ** 0.01 * 0.05

OR Annotation: Significantly > 1 Significantly <1

Blank cells with "/": NA, because those variables do not show in the final model using stepwise selection method with both directions.

Note: Race and Gender are not been selected in all three final models using stepwise selection method with both directions.

Performance

Prediction Error	0.3289	0.3248	0.3047

Conclusion

Higher Numeracy is related to Better Health

Self-Reported Health Status

Higher numeracy is related to better self-reported health status controlling other covariates in both ESP and PIAAC studies.

Healthcare-Provider Visits

- **Male:** Higher numeracy is related to less healthcare-provider visits controlling other covariates in ESP study.
- **Female:** There is no significant assocaition between numeracy and healthcare-provider visits in ESP study.

References

[1] Zikmund-Fisher, B. J., Smith, D. M., Ubel, P. A., & Fagerlin, A. (2007).Validation of the subjective numeracy scale: Effects of low numeracy on comprehension of risk communications and utility elicitations. Medical Decision Making, 27(5), 663-671.
[2] McNaughton, C. D., Cavanaugh, K. L., Kripalani, S., Rothman, R. L., & Wallston, K. A. (2015). Validation of a short, 3-item version of the subjective numeracy scale. Medical Decision Making, 35(8), 932-936.
[3] Fagerlin, A., Zikmund-Fisher, B. J., Ubel, P. A., Jankovic, A., Derry, H. A., & Smith, D. M. (2007). Measuring numeracy without a math test: development of the Subjective Numeracy Scale. Medical Decision Making, 27(5), 672-680.