

Research Articles

Are Patient Demographics, Linguistic Tones and Patient Reported Outcome Measures Associated with Health Literacy?

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Objectives

Limited ability to obtain, process, and understand health information that enables patients to make health decisions (low health literacy) is associated with worse health and an increased risk of hospitalization. There is evidence that patients' word choice can reflect illness behavior and care experience.

Correlation of linguistic tones and health literacy could help identify opportunities to ensure patient understanding and participation in decision-making during outpatient visits among patients with musculoskeletal illness.

Methods

A secondary analysis of transcripts of video and audio recordings of 65 adult patients seeking musculoskeletal specialty care was performed. Patients also completed questionnaires quantifying symptoms of depression (PROMIS [Patient-Reported Outcomes Measurement Information System] Depression computerized adaptive test [CAT]), PROMIS Pain Interference CAT (PI), PROMIS Upper Extremity CAT (UE), the Newest Vital Sign (NVS) health literacy questionnaire, and a basic demographics survey. Linguistic Inquiry and Word Count (LIWC) was used to detect the relative strength of various emotional tones, cognitive processes, and core drives and needs. We tested for associations between health literacy and patient demographics, each of the LIWC domains, and PROMIS Depression, PROMIS PI, and PROMIS UE.

Results

Accounting for potential confounding in multivariable analysis, higher health literacy was associated with greater years of education, greater tones reflecting anxiety, and greater tones describing risk. There were correlations between more limited health literacy and greater pain interference and greater symptoms of depression, but not with upper extremity-specific capability.

Conclusion

The observation that patient linguistic tones are associated with health literacy can be used to develop effective health strategies consistent with what matters most to patients.

Health literacy is the ability to receive, process, and comprehend basic information required to make appropriate health decisions.¹ Previous studies have shown that over a third of the United States (US) population has limited

health literacy.² Factors that correlate with lower health literacy include greater body mass index (BMI) and lower socioeconomic status, including greater distance between

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residence and nearest medical institution, lower monthly income, and lower education level.³

Natural language processing can analyze the content (themes) and tones in written language. It is possible that the language and tones a patient uses in a specialty visit correlate with levels of health literacy. If so, it might be possible to detect patient health literacy in the words and tone of their language, perhaps through computer analysis of their dialogue, and better strategize efforts to ensure understanding of their condition and the test and treatment options most consistent with their values.

STUDY QUESTIONS

Using a dataset of transcribed specialty care visits with corresponding measurements of patient health literacy, we asked: 1) Are there any patient linguistic tones or demographic factors associated with health literacy? 2) Are symptoms of depression, upper extremity magnitude of capability, and the degree to which pain interferes with capability associated with limited health literacy?

METHODS

STUDY DESIGN AND SETTING

With approval from our Institutional Review Board, we performed a secondary analysis of transcripts of audio or video recordings of 65 adult patients seeking musculoskeletal specialty care between November 2015 and March 2016, collected for other studies. In addition, participants completed a series of questionnaires after the visit.

All transcripts were separated into clinician and patient dialogue. Subsequently, Linguistic Inquiry and Word Count^{4,5} (LIWC, Pennebaker, University of Texas at Austin, USA) –an automated text analysis program– was used to detect the relative strength of various emotional tones, cognitive processes, and core drives and needs.⁶ LIWC can analyze written or transcribed verbal texts and compare each word against a user-defined dictionary. The percentage of words in each of the dictionary categories is calculated and compared to the total number of words in a text. For example, if LIWC identifies 15 words in the category ‘family’ (examples: aunt, uncle, nephew, niece) in a text with 100 words in total, the relative strength of this category would be 15%. For patient dialogue, we were interested in the following LIWC domains: the number of words, analytic thinking, confidence in understanding (clout), and authenticity, as well as the relative strength of tones consistent with positive emotion, negative emotion, anxiety, sadness, anger, social, family, cognitive process, insight, cause, tenacity, certainty, reward, and risk.

MEASURES

All patients were asked to complete the Patient Reported Outcome Measurement Information System (PROMIS) Depression computerized adaptive test (CAT), the PROMIS Pain Interference CAT (PI), the PROMIS Upper Extremity CAT (UE), the Newest Vital Sign (NVS) health literacy ques-

tionnaire, and a basic demographics survey (e.g., age, gender, marital status, work status, and years of education, etc.). PROMIS CATs are valid and reliable tools to assess a wide array of symptoms or limitations. People answer an average of 5 questions, with each new question based on the previously given answer, to arrive at a final score. A score of 50 represents the mean of the US general population, and every 10 points represents one standard deviation (SD).⁷

The PROMIS Depression CAT measures symptoms of depression on a continuum and is expressed as a t-score that is standardized to the US general population.⁸ A t-score of 50 represents the mean, and 10 above or below the mean represents one standard deviation. Higher scores indicate greater symptoms of depression. PROMIS questionnaires address illness on the continuum and in any context.⁹ The diagnosis of major depressive disorder can only be estimated with a questionnaire and is not a consideration in this analysis.

The PROMIS PI CAT (pain interference) instrument measures the effect of pain on all aspects of life: physical, mental, and social.¹⁰ In essence, it measures the extent to which pain hinders an individual’s engagement with physical, mental, cognitive, emotional, recreational, and social activities. The PROMIS UE CAT instrument measures activity intolerance of the upper extremity.¹¹ To measure health literacy, we used the NVS health literacy test. This test is based on an ice cream container nutrition label. Patients can achieve a score ranging from 0 to 6, where higher scores indicate greater health literacy. For this study, we categorized health literacy into limited understanding (0-3) and adequate understanding (4-6). We used the same threshold as in the original study of Weiss et al and four other recent studies.¹²⁻¹⁶ An NVS score less than 4 has a sensitivity of 100% and a specificity of 64% for predicting limited health literacy.¹²

PATIENT CHARACTERISTICS

Sixty-five patients were included with an average age of 52 years (interquartile range (IQR): 39-62) [Table 1].

Most patients were employed (N=38, 58%), and the majority were married (N=27, 42%). The average score for symptoms of depression was 48, which is close to the average population of the USA.^{8,17} The median years of education in this study group were 16 (IQR 12-18). The average score on the PROMIS Pain Interference CAT was 60 (1 standard deviation above the US population), and the average score of the PROMIS Upper Extremity Physical Function score was 35 (1.5 SD below the US population).

STATISTICAL ANALYSIS

Data were reported as median and interquartile range (IQR) for continuous variables and numbers (percentages) for categorical variables. We sought bivariate associations between NVS health literacy scores and patient demographics, Health literacy scores and each of the LIWC domains, and health literacy scores and PROMIS Depression, PROMIS PI, and PROMIS UE using Spearman rank order

Table 1. Patient Demographics (N = 65)

Variables	N (%)
N	65
Gender	
Women	24 (37)
Men	41 (63)
Marital	
Single	22 (34)
Living with Partner	3 (5)
Married	27 (42)
Separated or Divorced	12 (18)
Widowed	1 (1)
Work Status	
Working	38 (58)
Retired	11 (17)
Disabled/Unemployed	12 (18)
College	4 (6)
Variable	Median (IQR)
Age	52 (39-62)
Years of Education	16 (12-18)
PROMIS PI	60 (54-64)
PROMIS Dep	48 (45-53)
PROMIS UE	35 (30-40)

Continuous variables as median (interquartile range); discrete variables as percentage (number). PROMIS = Patient Reported Outcome Measurement Information System, UE = Upper Extremity, Dep= Depression, PI= pain interference

tests for all non-parametric continuous variables, Kruskal-Wallis tests for all multi-group categorical variables, and Mann-Whitney U tests for categorical variables consisting of two groups.

A post hoc power analysis demonstrated that a sample of 61 patients provides 80% statistical power to detect a Pearson correlation of 0.35 or higher with alpha set at 0.05.

RESULTS

FACTORS ASSOCIATED WITH NVS SCORES

Accounting for potential confounding between variables with $P < 0.10$ in bivariate analysis—including greater number of years of education [Appendix 1, Table 2], greater number of words used by patients, greater anxiety tones, and greater tones describing risk [Appendix 2, Table 3]—both greater anxiety and greater tones describing risk were independently associated with higher health literacy scores in multivariable analysis.

RELATIONSHIPS BETWEEN HEALTH LITERACY AND CAPABILITY AND SYMPTOMS OF DEPRESSION

More limited health literacy was associated with greater pain interference ($\rho -0.39$) and greater symptoms of depression ($\rho -0.37$), but was not associated with upper extremity specific capability [Table 4].

DISCUSSION

Limited ability to obtain, process, and understand health information, which enables patients to make health decisions (health literacy), is associated with worse health and an increased risk of hospitalization.¹⁸⁻²¹ There is evidence that a patient's word choice can reflect illness behavior and care experience.^{22,23} For instance, certain words and concepts are associated with feelings of worry or despair and unhelpful thinking.²⁴ Correlation of linguistic tones and Health Literacy could help identify opportunities to ensure patient understanding and participation in decision-making during outpatient visits among patients with musculoskeletal illness. We performed a linguistic analysis of transcripts of recordings of patients presenting for musculoskeletal specialty care. We found that a greater number of years of education, a greater number of words used by patients, higher levels of anxiety, and higher levels of risk perception were associated with greater health literacy scores.

This study has several limitations. All patients were enrolled from a single large urban area, which may limit generalizability, though our demographic data suggests that there was adequate diversity to identify statistical associations. Second, idiosyncratic elements of speech, such as stutters, repetition, pauses, nonverbals, and involuntary vocalizations, do not contribute to the measured linguistic tones. The verbal and nonverbal cues in combination with the actual words spoken — known to convey patients' mood and coping strategies—might also better represent health literacy but are missed in this analysis. LIWC also does not pick up on sarcasm, idioms, or jokes, which may lead to misclassification of certain dialogue. This can be considered a first step in the attempt to use NLP to assess health literacy and its effect on care. Third, people behave differently under observation (Hawthorne effect),²⁵ which could affect the topics that patients feel comfortable discussing with their physician,²⁶ perhaps this is particularly true when people are being recorded. Although there is evidence that Hawthorne effects have a limited influence on experiments.²⁷

The observation that greater health literacy was independently associated with greater tones of anxiety and greater tones describing risk may at first seem to contradict the evidence of the correlation of fewer symptoms of anxi-

Table 2. Multivariable analysis of NVS scores and Years of education

Variable	β	Standard Error	t	P
Years of education	0.32	0.085	3.7	<0.001

Continuous variables as median (interquartile range); discrete variables as numbers. All significant correlations in bold. NVS= Newest Vital Sign

Table 3. Multivariable analysis of NVS scores and LIWC Dimensions

Variable	β	Standard Error	t	P
Word count	0.0076	0.00047	1.6	0.11
Anxiety	2.8	0.87	3.21	0.002
Risk	1.38	0.56	2.5	0.017

Continuous variables as median (interquartile range); discrete variables as numbers. All significant correlations in bold. NVS= Newest Vital Sign, LIWC= Linguistic Inquiry and Word Count

Table 4. Correlations between Patient Reported Outcome Measures and NVS scores

	PROMIS PI		PROMIS Depression		PROMIS UE	
	Median	P	Median	P	Median	P
NVS Score		0.0013		0.0024		0.19
Limited	62 (56-68)		53 (48-58)		33 (26-38)	
Adequate	59 (53-64)		46 (39-52)		36 (32-41)	
ρ		-0.39		-0.37		0.17

Continuous variables are presented as median (interquartile range [IQR]). PROMIS = Patient Reported Outcome Measurement Information System. PI = Pain Interference. Dep = Depression. UE = Upper Extremity, NVS=Newest Vital Sign, ρ = correlation coefficient. All significant correlations in bold.

ety with greater health literacy.²⁸⁻³⁰ Perhaps people experiencing greater feelings of worry or despair are less able to articulate their feelings.³¹ This is consistent with evidence that people with more symptoms of depression tend to avoid expressing negative emotions.³² Not acknowledging one's emotions and emotional avoidance strategies, such as emotional suppression, are mediators of a variety of psychological illnesses, including depression.³³ Furthermore, ineffective cognitive coping strategies and the inability to regulate negative or aversive emotions are associated with symptoms of depression,^{34,35} and there is evidence that the lack of emotional clarity (i.e., the extent to which individuals can identify, label, and express emotions) can worsen depressive symptoms.³⁴ It may sound counterintuitive that patients with greater symptoms of depression express less emotion. Still, it is in agreement with previous studies that indicated that emotional numbness and less expression of emotion in general can be indicative of major depressive disorder³⁵—especially in men.³⁶ One study found that among both undergraduate students and patients being treated for mood disorders, both inhibition of emotional expression and suppression of unwanted thoughts were associated with symptoms of depression and hopelessness.³⁷ Or perhaps greater tones describing risk and anxiety reflect considerations specific to the symptoms, unrelated to general feelings of anxiety. The fact that these tones were picked up may relate to the fact that patients more involved with their health ask more questions^{13,16,38,39} and have longer visits¹⁶ in which more details are discussed.

The observation that more limited health literacy was associated with greater symptoms of depression and greater pain interference is consistent with previous research demonstrating that worse mental health is associated with more limited health literacy and worse health status.⁴⁰ One key aspect of health literacy may be an un-

derstanding of the normal functioning of the human mind, mental short-cuts in particular. An awareness that the mind's guessing apparatus—designed for quick, pressing decisions—may, at times, need to be overruled and ideas rethought (analytical/critical thinking) seems to be a key aspect of effective accommodation and good health. The construct of pain interference is strongly associated with unhelpful thinking patterns such as catastrophic thinking, kinesiphobia, and low self-efficacy.⁴¹ The ability to ameliorate unhelpful thinking may be a key aspect of health literacy.

The observation that a person's language can reflect their health literacy may point to new approaches to health and health strategies. If clinicians or clinical tools, such as computer analysis of spoken language, facial expression, and other aspects of speech (tone, cadence, etc.), identify evidence of limited health literacy, the next thought might be about a person's critical thinking skills and ability to move from their default mindset to a healthier mindset.

CONCLUSION

We can build on the evidence that unhelpful thoughts (misconceptions) about symptoms are associated with greater discomfort and incapability, understand that patient verbal and non-verbal cues can signal unhelpful thinking, and cultivate in all clinicians the ability to recognize unhelpful thinking and used crafted strategies for gently and incrementally reorienting important misconceptions, always mindful that suggesting new ways of thinking can be uncomfortable and are a risk to a healthy patient-clinician relationship.

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DECLARATION OF CONFLICT OF INTEREST

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DECLARATION OF ETHICAL APPROVAL FOR STUDY

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DECLARATION OF INFORMED CONSENT

There is no information in the submitted manuscript that can be used to identify patients.

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APPENDICES

Appendix 1. Bivariate Analysis between Patient Demographics and NVS Scores

	Limited Health Literacy	Adequate Health Literacy	P
Gender			0.35
Women	5	19	
Men	13	28	
Marital			0.69
Single	7	15	
Living with Partner	0	3	
Married	8	19	
Separated or Divorced	3	9	
Widowed	0	1	
Work Status			0.56
Working	9	29	
Retired	4	7	
Disabled/Unemployed	5	7	
Collage	0	4	
Age	49 (39-64)	52 (37-59)	0.84
Years of Education	12 (12-16)	16 (15-18)	<0.001

Continuous variables as median (interquartile range); discrete variables as numbers. All significant correlations in bold.

Appendix 2. Correlations between LIWC Dimensions and NVS scores

LIWC Dimension	Example Language	Limited Health Literacy	Adequate Health Literacy	P
Word Count		302 (153-411)	420 (239-753)	0.047
Analytic		16 (10-27)	11 (8-22)	0.14
Clout		23 (14-37)	18 (11-29)	0.17
Authentic		70 (59-92)	82 (71-92)	0.26
Posemo	love, nice sweet	5 (3-9)	4 (3-7)	0.92
Negemo	hurt, ugly, nasty	1.3 (0.92-2)	1.7 (1.2-2.6)	0.13
Anxiety	worried, fearful	0 (0-0)	0.24 (0-0.47)	<0.001
Anger	hate, kill, annoyed	0 (0-0.55)	0.1 (0-0.3)	0.72
Sad	crying, grief, sad	0.3 (0-0.7)	0.42 (0-0.85)	0.49
Social	mate, talk, they	5.5 (3.5-7.6)	4.9 (3.8-6.7)	0.62
Family	daughter, dad, aunt	0 (0-0)	0 (0-0.16)	0.095
Cogproc	cause, know, ought	10 (8-12)	13 (10-14)	0.006
Insight	think, know	1.4 (0.7-3.3)	2.6 (1.8-3.2)	0.05
Cause	because, effect	1.4 (0.65-2.4)	1.3 (0.61-2)	0.75
Tentat	maybe, perhaps	2.4 (1.8-2.7)	2.9 (2.2-3.9)	0.062
Certain	always, never	1.2 (0.32-1.7)	1.1 (0.6-1.8)	0.64
Reward	take, prize, benefit	1.3 (0.65-1.9)	1.5 (0.93-2.3)	0.19
Risk	danger, doubt	0.17 (0-0.37)	0.53 (0.24-0.78)	0.003

Continuous variables are presented as median (interquartile range [IQR]). LIWC = Linguistic Inquiry Word Count. Analytic = summary variable for analytic thinking. Clout = a summary variable that reflects the confidence in the text. Authentic = summary variable to understand the tone of discourse. All significant correlations in bold.