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Health literacy

Relevance of graph literacy in the development of patient-centered communication tools

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ABSTRACT

Objective: To determine the literacy skill sets of patients in the context of graphical interpretation of interactive dashboards.
Methods: We assessed literacy characteristics of prostate cancer patients and assessed comprehension of quality of life dashboards. Health literacy, numeracy and graph literacy were assessed with validated tools. We divided patients into low vs. high numeracy and graph literacy. We report descriptive statistics on literacy, dashboard comprehension, and relationships between groups. We used correlation and multiple linear regressions to examine factors associated with dashboard comprehension.
Results: Despite high health literacy in educated patients (78% college educated), there was variation in numeracy and graph literacy. Numeracy and graph literacy scores were correlated ($r = 0.37$). In those with low literacy, graph literacy scores most strongly correlated with dashboard comprehension ($r = 0.59$–0.90). On multivariate analysis, graph literacy was independently associated with dashboard comprehension, adjusting for age, education, and numeracy level.
Conclusions: Even among higher educated patients; variation in the ability to comprehend graphs exists.
Practice implications: Clinicians must be aware of these differential proficiencies when counseling patients. Tools for patient-centered communication that employ visual displays need to account for literacy capabilities to ensure that patients can effectively engage these resources.

1. Introduction

Beyond measuring reading skills, health literacy is the degree to which patients have the capacity to obtain, process, understand and use health information [1,2]. Limited health literacy is associated with increased use of emergency care, hospitalizations, medical non-compliance, poorer health status, higher health care costs and mortality [3–7]. Notably, an estimated 9 of 10 Americans have limited health literacy [8], which leads to patients being less able to exert control over their own care [9,10]. This concerning finding is incongruent with the priorities set forth by the Institute of Medicine to deliver high quality, patient-centered care [11,12]. One approach to engaging low literacy populations is the use of informatics resources that enhance the delivery of patient-centered care by communicating information with the use of interactive computer programs, decision aids, or print materials [13,14]. Often this enhanced communication is accomplished with graphs or charts [15,16], yet the adequacy of requisite skill for patients to utilize these graphical tools is understudied.

Health literacy for written text is considered essential to quality health care, yet we know far less about other forms of literacy, including numeracy [17] and the ability to interpret graphs [17–19]. In contrast to numeracy for textual health information [17], graph literacy requires the ability to understand information from two-dimensional images, including sketches, photographs, diagrams, maps, plans, charts, and graphs [20,21]. Fundamental dimensions of graph literacy include the ability to *read the data* (i.e., extract information from a graph), *read between the data* (i.e., compare data between groups represented on a graph), and *read beyond the data* (i.e., make predictions of future outcomes based on a graph) [22]. Although related, each form of literacy (i.e., health literacy, numeracy, graph literacy) represents a distinct skill set.

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We explored the use of charts and graphs in the design of quality of life "dashboards" to promote patient-provider communication by displaying trends in health-related quality of life (HRQOL) following prostate cancer treatment. We applied human-centered design principles to develop a design concept for a digital tool called "*QOL Tracker*" that captures patient-reported outcomes for prostate cancer-specific HRQOL and visually presents longitudinal HRQOL scores contextualized with the scores of matched men [23]. To inform dashboard design, patients completed literacy assessments and evaluation of candidate dashboard comprehension mapped to fundamental dimensions of graph literacy [23]. Pilot evaluation of QOL Tracker demonstrated higher compliance with quality indicators for prostate cancer care among patients exposed to QOL Tracker prototypes than unexposed patients [24].

Our developmental work showed that, despite high health literacy, our highly educated patient population had graph literacy abilities that were consistent with population averages and had comparable *reading* and *reading between* scores, but significantly lower *reading beyond* scores compared with health care providers [23]. An analysis of the graph literacy capabilities of patients, the interrelationships between graph literacy and other aspects of literacy, and identification of factors that are associated with poor graph literacy could help tailor future patient-centered design efforts.

The aim of this study was to determine the relationship between numeracy, graph literacy, and dashboard comprehension in a cohort of prostate cancer patients. Understanding how levels of numeracy and graph literacy relate to dashboard comprehension could better inform clinicians who utilize these resources and may help shape the development of future tools. Further, understanding predictors for comprehension of visual formats may help better identify those who may encounter difficulties interpreting these resources.

2. Methods

2.1. Population

The study sample consisted of patients with prostate cancer at any stage and any time since treatment. We recruited patients who could read and understand English from prostate cancer support groups in the Seattle metropolitan area. This study received approval from the University of Washington Institutional Review Board.

2.2. Procedures

Through individual interviews, we collected participant demographics including age, race, marital status, and education level as well as clinical information, including prostate cancer treatment type and years since primary treatment. We then assessed participant literacy and measured dashboard comprehension and preferences among three graph formats: table, line and bar graphs.

Literacy assessment measured participant health literacy, numeracy, and graph literacy. We measured health literacy with the short-form version of the Rapid Estimate of Adult Literacy in Medicine (REALM), which assesses medical word recognition and pronunciation [25]. We measured numeracy with the Subjective Numeracy Scale (SNS), and graph literacy with the Graph Literacy Scale (GLS). SNS is an 8-item measure that assesses subjective perceptions about mathematical ability [26]. Responses are scored 1–6 to generate an overall score (i.e., average score across all 8 questions) as well as 2 subscale scores for numerical ability and preference. GLS is a 13-item measure that assesses understanding of common graphical formats across three dimensions: reading, reading between, and reading beyond the data [21]. Responses are marked as correct/incorrect and four scores are generated: the overall score is the percent correct across all thirteen questions and subscale scores are the percent correct for questions corresponding to each of the three dimensions of graph literacy (i.e., reading, reading between, reading beyond).

Following literacy assessment, we evaluated comprehension of three alternative dashboard formats: table, bar chart, and line graph, examples of which have been previously published [23,24]. Each dashboard illustrated sample HRQOL data for a fictitious patient scenario (Fig. 1). Participants viewed each dashboard and responded to questions that targeted the 3 dimensions of graph literacy. For example, we asked participants to determine the HRQOL score shown at points before and after treatment to assess "*reading*", to describe the relationship between HRQOL trends to assess "*reading between*", and to make a projection about future HRQOL based on score trends to assess "*reading beyond*" the data. We marked responses as correct/incorrect to generate percent correct scores for *overall*,*reading*, *reading between*, and *reading beyond* for each dashboard format. We presented dashboards in random order and counterbalanced between participant for positive and negative framing (i.e., the fictitious patient was doing better or worse than the comparison group of patients). Finally, we asked patients to rank order the dashboards in order of preferred format.

2.3. Analysis

We summarized participant characteristics, literacy, and dashboard comprehension with descriptive statistics. To compare patients with lower vs. higher literacy, we stratified the analysis in two ways. We constructed a first model that divided participants into two groups: those with "high numeracy" (SNS score $>$ 4.0) compared with those with limited to moderate numeracy (SNS $\leq$ 4.0), which we refer to as "low numeracy". Numeracy was treated as a continuous variable, with stratification into high and low numeracy determined from previous studies [19,27]. We constructed a second model in which we stratified participants by GLS score. We defined "high graph literacy" by GLS $>$ 66% and limited to moderate graph literacy as GLS $\leq$ 66% (i.e., "low graph literacy") [19]. We compared participant characteristics between groups with *t*-tests, Mann–Whitney-*U*, and Fisher's exact tests. We then examined whether patient numeracy and graph literacy correlated with dashboard comprehension with Pearson rank correlation. We also applied multivariable regression with generalized estimating equations to determine the association between age, education level (college educated or not), numeracy score and GLS score on dashboard comprehension. All statistical analyses were conducted with Stata (Stata Corp., College Station, version 14).

3. Results

3.1. Demographics

We interviewed 50 prostate cancer patients, consisting of predominantly older, college-educated, married, Caucasian males. A significantly higher proportion of non-white participants were in the low numeracy and low graph literacy groups (Table 1).

3.2. Literacy assessment

The mean REALM score for entire cohort was 6.8/7.0 (SD 1.0). Given our highly health literate population we excluded REALM from subsequent analyses to prevent over-fitting our models. The